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PSYCHOLOGY OF LEARNING

A Textbook in Educational Psychology

BY

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PREFACE

This book is developed around the general theme of learning and its applications to education. Each chapter is developed inductively so that the student may test the soundness of the conclusions on the basis of the evidence. Generalizations are made wherever they are justified by the facts. No attempt has been made to represent any particular school of thought or point of view in psychology, but rather the aim has been to make the book rest solidly upon experimental work. It does not propose a new theory of learning nor strive primarily to encourage speculation concerning learning from a theoretical viewpoint. In a field which is growing as rapidly as educational psychology and where definite laws are difficult to establish, an attempt to build a text around any particular school of thought would be unwise, for it might lead to the belief that there is only one correct point of view, and thus thwart the problem-solving attitude on the reader's part. At most, generalizations are only hypotheses which are the best guesses resulting from the integration of all pertinent data; and in educational psychology, where conclusions from objective investigations are constantly modified, generalizations are necessarily tentative.

The book is intended as a text for both undergraduate and graduate students in departments of education and psychology. For students of education it may serve as a text in educational psychology while for students of psychology it may be used as a text in the psychology of learning. It presupposes some knowledge of psychology as well as of scientific techniques and statistical devices, although references to standard works in technical chapters should enable the student to obtain further information if needed. Many topics such as individual differences, statistics and mental measurements are purposely

omitted because they are usually treated in special courses. Rather the aim has been to present those topics which most closely relate to learning and teaching.

It is hoped that school people in particular will be able to use in a practical way some of the conclusions derived from objective investigations, and may be stimulated to conduct studies along the lines of their greatest interests. More studies are needed which deal with children who range from the kindergarten stage through the adolescent period. The social phases of learning and education as a whole can best be understood when studies are conducted under schoolroom conditions.

Many persons have contributed to the work of this book. Graduate students of educational psychology and methods of research at the University of Colorado have been a constant source of inspiration and help. The author feels he is fortunate to have had, during his training, courses under Professors J. F. Dashiell and A. M. Jordan of the University of North Carolina, who read the manuscript and made many constructive suggestions. Professor Herbert A. Clugston of Minnesota State Teachers College of St. Cloud, while a Fellow at the University of Colorado, made an intensive study of the literature on learning, a great part of which has been incorporated in Chapters IV and V. He also contributed largely in the writing of these chapters. The author's greatest indebtedness is to Mr. A. M. Vance, of Boulder, who assisted with every chapter and helped in many invaluable ways. Messrs. Alfred Horsch and David Dorlester, graduate students of the university, rendered much assistance during the final stages of preparation. The author's wife, Maude Cochran Davis, gave unstintingly of her time in critically reading the manuscript and in improving the style of presentation at every stage of writing.

ROBERT A. DAVIS.

THE UNIVERSITY OF COLORADO,
March, 1935.

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FOREWORD

Through the instrumentality of a host of workers, attested information concerning the growing child and his learning has increased at such a rapid rate that today it is an impossible task to cover the material adequately in one course. Where before there were three or four studies on a topic, there are today twenty or thirty or even, in some cases, forty or fifty. This plethora of material has brought on a distinct need for an advanced course in educational psychology.

Then, too, there is a growing body of sincere students who would like to examine more critically the security of the foundations on which their first course rested. To do this requires careful weighing of studies whose results are somewhat divergent as well as consideration of some of the many theories advanced on disputed points. To give such students this opportunity has been the moving purpose in the present text.

This book introduces its readers to a majority of the better studies and to most of the more promising theories on the psychology of learning processes. The neurological explanations of learning, for example, have been doubly confused by the more recent findings regarding brain localization and the general functioning of the cerebral cortex. In such a dilemma several theories have arisen from which four have been selected here. All through the text the student is encouraged to evaluate critically the theories and studies presented. A good illustration of this procedure occurs in the discussion of the achievement quotient, where, instead of rejecting this concept because of its apparent weaknesses or blindly swallowing it whole, good and bad together, many different studies of it are briefly reviewed and critical suggestions offered.

This opportunity for evaluating the contribution of a great number of studies is enhanced by the frequent presentation of

tabular summaries. In these summary tables the essence of each study is set forth in a brief space in such a way as to enable the reader to obtain the trend of them all, if there is a trend, or to be sure that the whole question is unsettled because of the mélange of results. After these theories and studies have been considered, some practical applications are drawn from them so that the student is not left suspended among three or four rival theories or disagreeing findings.

A. M. JORDAN.

THE UNIVERSITY OF NORTH CAROLINA,
March, 1935.

PSYCHOLOGY OF LEARNING

CHAPTER I

THE OBJECTIVES AND METHODS OF EDUCATIONAL PSYCHOLOGY

The application of psychology to education was the result of an early realization that progress in education should be based upon psychological principles. Baldwin[1] in 1889 stated that no teacher could become more than a copyist who did not understand the principles of psychology and apply these to his teaching. He believed that teaching should be conducted by "leading the learner to build on his own experience." In 1895 Roark[2] affirmed that "psychology sustains the same relation to the science of education that anatomy, physiology and pharmacy sustain to the practice of medicine." He believed that it was just as essential for the teacher to understand the mind's activities as it was for the physician to know the functions of the bodily organs.

Experimental study in educational psychology owes its inception to the German school as represented by the classical works of Ebbinghaus and Meumann. These investigators not only established working hypotheses upon which later investigation has been developed but made possible the formation of principles which are as valuable today as when they were first formulated. The early work of these German scholars, while limited primarily to memory, supplied the foundation for study of educational psychology in this country.

[1] Baldwin, Joseph, *Elementary Psychology and Education*, New York, Appleton, 1889.

[2] Roark, R. N., *Psychology in Education*, New York, American Book Company, 1895.

Thorndike[1] is a pioneer in educational psychology in the United States. Although in the beginning of his career his interests were directed primarily to the learning of animals, his results established laws and principles of learning which were later confirmed by experimentation with human subjects. As early as 1903 Thorndike achieved an epoch-making work in summarizing and interpreting the important available objective data of that time. It was in this early work that Thorndike emphasized the importance of building up an educational science on the basis of inductive and especially quantitative methods of study. "A true educational science must be made up from the study of the particular facts in answer to thousands of different questions." He believed that education to become a science should emphasize the construction of adequate measuring instruments so that controlled investigations might be conducted under schoolroom conditions. Objective instruments he believed were necessary for adequate description of individual differences and statistical devices were necessary in their interpretation. It was this emphasis upon experimental study and adequate description of individual differences that characterized his early work. Some typical problems of investigations suggested by him during these early years included mental measurement, the distribution and relationship of mental traits, the influence of heredity and environment, sex differences and mental growth.

Thorndike's *Educational Psychology* represented the earliest effort to organize the literature in the field, suggested methods of objective study and led to the development of his three-volume edition of *Educational Psychology*. With the appearance of these books educational psychology was placed upon a more solid foundation, and it is noteworthy that a large part of original material presented in these volumes was the result of Thorndike's own investigations. It was clear from these early books that he believed the principal contribution of educational psychology was in supplying principles which deal with learning and, indirectly, teaching.

[1] THORNDIKE. E. L., *Educational Psychology*, New York, Science Press, 1903.

Research in educational psychology has shown a steady and consistent growth, and although there has been a wide diversity of interest in research projects the aims of the field are essentially the same as those formulated 25 years ago. The chief purpose of educational psychology is to develop facts and principles which will form the basis for economical methods of learning and teaching.

A. Objectives of Educational Psychology

1. Teaching Objectives.[1]—In establishing objectives in educational psychology, it is assumed that the student has been prepared in basic courses, and in those topics usually covered in general psychology. He should possess some of the pertinent facts dealing with physical and mental growth and emotional and social reactions as they apply to childhood and youth. In general the student should have some appreciation of the intricate inner life of the individual which would create insight and sympathy for the growing mind. These are minimum requirements, and considerably more training in the techniques of experimental research and psychology would be needed for those students of advanced standing who intend to carry forward work for higher degrees in education or psychology. For advanced students the objectives would necessarily differ from those outlined for prospective high-school teachers who expect educational psychology to contribute toward their professional training. Irrespective of the maturity of the student, the following statements represent the chief teaching objectives in educational psychology. Educational psychology aims:

a. To Develop an Understanding and Appreciation of the Hereditary and Environmental Factors Which Underlie Learning Ability.—Investigations dealing with the influences of heredity and environment should be evaluated with emphasis placed upon mental rather than biological traits. It is also essential to understand the nature of improvement and to evaluate the

[1] A part of this material appeared in *J. Educ. Psychol.*, 1933, **24**, 189–194.

theories proposed for its explanation; to understand the relationship of mental processes, the nature and significance of intelligence and the character of learning ability.

b. To Provide Bases for Understanding the Nature and Principles of Learning and to Supply the Techniques for Its Improvement.—An interpretation of physiological and psychological learning should be considered with the theories of learning and the factors which influence economy in the learning process. The student should have practice in the application of these learning principles to classroom conditions and should develop ability in the selection and application of techniques which will elicit the most favorable learning responses.

c. To Develop Ability in the Recognition of the Different Types of Learning and in the Application of These Types to the Various Fields of Subject Matter.—Educational psychology should develop the ability to differentiate and to apply principles concerning the types of learning applicable to the different school subjects. Emphasis should be given to the mental learning employed in mastering abstract subjects, and also to problem solving and reflective thinking.

d. To Understand and Appreciate Factors Influencing Individual Ability to Learn.—The part played by the development of perception, observation and report should be noted. Other factors include the influence of physical traits and various types of sensory defects upon ability and achievement. Although these factors are susceptible to training and education, they are primarily a phase of native equipment, and may, therefore, be considered as predominantly inherent in character.

e. To Provide Understanding of the External Factors Which Are Largely within the Control of the Teacher and School.—These external factors include modes of presentation as related to reception of stimuli, the use of guidance techniques in learning, the influence of continuous work and fatigue, attitudes, motivating devices, transfer and techniques of study. Improvement may be produced by the development of techniques of studying and learning and by the provision of favorable school environment.

f. To Provide Skill in the Methods of Measuring Achievement and in Evaluating Teaching Efficiency.—Educational psychology should not only develop techniques for producing learning, but it should also provide skill in measuring achievement and the effectiveness of teaching methods. This aim emphasizes the significance and use of objective measurement for estimating the amount and quality of pupil achievement for definite periods of instruction. Through the use of objective measuring instruments, the teacher can test the relative effectiveness of her methods and techniques of teaching.

g. To Develop an Appreciation of the Individual.—At every stage in the guidance of learning, the individual should be kept in mind, together with the recognition that the discovery of individual differences is a function of the program of mental hygiene. This recognition implies a study of the physical, mental, emotional and social traits, a combination of which constitute the individual's personality.

2. General Objectives.—There are also general objectives which should be observed at the outset of study in educational psychology. These objectives include information, attitudes, skill and appreciation which in a degree are common to all fields of education. Educational psychology aims:

a. To Provide a Body of Facts and Methods Which Can Be Used in Solving Teaching Problems.—Educational psychology is a pioneer among the fields of education in the use of objective tools and devices, and experimental methods of research have been the chief means by which problems in this field have been studied. The student should acquire a fund of information from his study and possess some knowledge of the methods and techniques used by investigators for arriving at the findings from which that information has been obtained.

b. To Develop the Scientific and Problem-solving Attitude.—Owing to the controversial nature of the problems in the field of educational psychology and the refinement of tools and techniques used in the study of these problems, the conclusions of research studies are constantly modified. It is important that the student study educational psychology with the attitude to

accept as final only those conclusions for which definite proofs are available.

c. To Train in Thinking Psychologically about Educational Problems.—Psychological principles apply to the pupil who is the learner, and to the teacher who organizes materials of instruction and motivates learning. One should, therefore, think in psychological terms of pupils, teachers and methods of teaching as they are functionally related.

B. Educational Psychology as a Science

Although educational psychology is one of the earliest fields of education to receive technical treatment and already contains a large body of scientific material, it deals with processes and factors of learning which are elusive phenomena and consequently it is handicapped by many obstacles. These obstacles include the difficulty of developing accurate measuring instruments and the control of a large number of variable elements which may influence results and conclusions. Studies in this field must therefore be supported by many checks before findings are trustworthy. The variables to be safeguarded against include the subjects used, the methods of measurement and the professional training and experience of those who conduct investigations. The nature of human behavior introduces factors which are difficult of measurement and control whether they are observed under laboratory or schoolroom conditions. In general, educational psychology uses scientific methods and techniques, but its principal methods are peculiar to its own field. Experimental and descriptive methods are most commonly used.

1. The Experimental Method.—An experiment is an observation which can be repeated, varied and isolated. The observer is not only able to control phenomena under observation, but can produce them when he desires. The experimenter is able to produce in his laboratory conditions under which certain responses may be elicited. He may modify these conditions and observe different results under varying circumstances, repeat former experiments under similar conditions

and make comparative analysis of results. Experimentation enables the observer to enhance his powers of observation and at the same time modify control over his phenomena.

The experimental method of research which is most important in educational psychology is used primarily to test and evaluate hypotheses. Its function is the evaluation of aims, materials and methods employed in learning and teaching. The characteristic which distinguishes this from other methods employed in educational psychology is the application of experimental factors to individual pupils, class groups and school systems under controlled observation. Controlled group experiments have two characteristics: (1) there are one or more experimental groups; and (2) these groups are subjected to experimental factors under controlled conditions. Extraneous factors such as traits of teachers, time of day, materials of study, age of pupils and size of classes may influence the results which are obtained. These factors may be controlled by techniques of equating and rotating or they may be partially accounted for by means of statistical procedure. Experimentation determines the influence of experimental factors by measuring the status of the groups before and after the experimental factors have been applied. The difference between the initial and final status of the groups having been determined, there is the further step of ascertaining the reliability of the difference obtained.

2. The Descriptive Method.—The descriptive method of research differs from the experimental in that it is a description of the existence and status of facts and conditions with little control over the facts under investigation. In experimental study there is implied a change, represented by a "before" and an "after" condition, which is due to the influence of one or more experimental factors. In descriptive research facts are studied as such without determining by controlled observation the influence of factors operating to affect causal relationships. The only control measures developed by the investigator who employs the descriptive method involve the selection of individuals or groups for study, the choice and refinement of instruments of measurement, and the application of statistical

devices for describing and interpreting data. The experimental and descriptive methods may easily be confused because they employ essentially the same types of measuring instruments and statistical devices.

A typical example will serve to differentiate the two methods of investigation. A descriptive study was made by Mallory who investigated the relation between several physical defects and achievement of elementary-school pupils. Standardized tests were employed for the measurement of achievement and the physical examinations were conducted by a trained nurse. In studying the data so derived, Mallory[1] determined the relation between physical defects and achievement by statistical formulas designed to show numerical relationship. Since the coefficients indicating this relationship were significant, he concluded that physical defects have direct bearing upon progress in school. The method consisted largely in the study of two groups of facts as they existed, the only control exercised being the selection of a group of typical children, the choice of instruments for measuring achievement and physical defects and the application and interpretation of statistical formulas. There was no effort to determine the change in achievement which might have resulted from the removal or correction of physical defects in children.

By contrast consider a study by Rogers. The method employed by Rogers[2] was that of measuring changes in intelligence following the removal of pupils' adenoids and tonsils. Two groups of children were selected for study, one group having diseased tonsils and the other group being free from them. By comparing the changes in intelligence for the group operated upon for diseased tonsils with the group used as control six months after operation, the influence of the operation upon the growth of intelligence was determined. In this study may be noted the essential characteristics of the experimental

[1] MALLORY, J. N., A study of the relation of some physical defects to achievement in elementary school, *Peabody Coll. Teach. Contrib. Educ.*, 1922, 9.

[2] ROGERS, MARGARET C., Adenoids and diseased tonsils: their effect on general intelligence, *Arch. Psychol.*, 1922–1923, 50.

method. Control factors and change were introduced in Rogers's study as safeguards, and the influence of the operations for diseased tonsils and adenoids was noted.

The descriptive method has enjoyed wide popularity in the study of educational psychology problems and may be illustrated by a number of patterns or techniques. The study cited by Mallory illustrates the technique which compares individuals or groups in one trait with the same individuals or groups in another trait. There is also the technique which employs one individual and compares traits of the same individual as in intensive case studies. The descriptive method is also illustrated by the survey technique which is commonly employed by school boards and superintendents in measuring the efficiency of school systems. Descriptive research as exemplified in measuring the efficiency of school systems may be either general or partial. A survey may be made of the entire system or any part of a system or a problem within a system. These surveys are either subjective or objective. A subjective survey is merely a compilation of personal opinions by observers and possesses questionable merit. The objective survey employs all the instruments of measurement, techniques and statistical devices applicable to the situation and its recommendations are usually reliable.

Descriptive research is frequently used in studying problems of educational psychology because of its convenience and adaptability. It is not so valuable as the experimental method because it makes little attempt to control observation and consequently is not definitely able to indicate cause and effect relationships. However, to the degree to which it employs reliable instruments of measurement and studies representative groups of subjects, it is a valid method of study.

3. Tools and Devices.—Whether the investigator employs the experimental or descriptive method, the value of his findings is largely dependent upon the tools and devices[1] which are employed. Since there is now available a large number of

[1] DAVIS, ROBERT A., Research and the schools, *J. Educ. Res.*, 1933, **26**, 561–568.

objective tests representing all subjects and grades, the selection of tools in research is a problem in itself. The *personal interview* and the *questionnaire* are extensively used as a means of gathering data but they should be checked for reliability and validity before they are used as instruments of research. *Rating scales* are extensively used but should be studied adequately for accuracy and adaptability to research problems. When appropriate tools are not available, some must be skillfully constructed and critically evaluated before being used. Many tools used in both psychological and educational investigations are so low in reliability that regardless of the outcomes of the studies the results are inconclusive. The reliability of tools having been established, there is the further problem of determining their validity because we are never sure that the criteria used for the establishment of validity are in themselves valid.

An important consideration with regard to devices is the choice and interpretation of statistical formulas which are appropriate for the data, for statistical devices are often incorrectly interpreted even when appropriately employed. New statistical formulas are being devised continually and old formulas are constantly being refined. The derivation of such formulas is a task for a restricted group, and the most important consideration is that the investigator know when and how to use them.

4. **Introspection.**—Although introspection has been largely supplanted by objective methods of observation, it serves a definite purpose.

For example, O'Brien[1] sought to determine the efficiency of several modes of presentation for learning meaningful words and nonsense syllables. The objective results of his study are accompanied by a detailed analysis of the introspective records of the individuals used in the experiment. Irrespective of the results which may be obtained by means of refined measures or by the control of experimental factors, the wise investigator recognizes the limitations of objective findings and is interested

[1] O'Brien, F. J., A quantitative investigation of the effect of mode of presentation upon the process of learning, *Amer. J. Psychol.*, 1921, 32, 249–283.

in his subjects' own observations of their intellectual and emotional reactions.

The introspective method has been discredited by some chiefly on the ground that it is subjective, and, consequently, unreliable. However, the criticisms which have been made against introspection have usually been similar to those directed against the method of "outward" observation. The unreliability of "outward" observation may be due to a number of factors including lack of training on the part of those who observe, their prejudice and bias and the brevity of events being observed. In general, the reliability of observation may be increased when the observer plans his observation, is equipped to record accurately his experiences at the time they occur and is able to repeat his observations at frequent intervals. The ability to observe is very definitely improved by training in observation, and the most effective training is specific in character. If training in outward observation produces greater reliability, it may be supposed that definite training in introspection would also result in improvement. As DeSilva[1] states: "Even though his material is supposed to be given him directly, a beginner's observations in psychology are as useless as a beginner's observations in histology." Introspection is a valuable method in psychological investigation and effort should be made to train individuals so that it may function more satisfactorily as a concomitant of objective research. It can be made to contribute an important part in the interpretation of objective results wherever human subjects are involved.

C. Sources of Data in Educational Psychology

Educational psychology is indebted to numerous fields for its data. In addition to the direct contributions of studies covering various levels and fields of education, it is under obligation to physiology, psychology, sociology and to certain phases of medical science. For the neurological explanations of learning, it is indebted to physiology; for the various psycho-

[1] DeSilva, Harvey R., The common sense of introspection, *Psychol. Rev.*, 1930, 27, 71–87.

logical aspects of learning and its factors, the psychological field is an indispensable original source of information. In some aspects of learning, sociological investigations contribute a substantial share of original data. The field of medical science affords valuable investigations on the physical factors which influence learning.

Educational psychology has drawn heavily upon results obtained from animal experimentation. However, the most ardent enthusiast for animal psychology would be willing to direct his efforts to the study of human beings if he were able to establish supervisory controls with the same accuracy which obtains in the study of animals. Were it possible to secure children of various ages and degrees of maturity and subject them to laboratory conditions, the results of scientific investigations would be far more applicable to the learning process and to education in general. It is a striking fact that psychological investigation has been devoted mainly to two extreme divisions of subjects—animals and college students—and both are unsatisfactory for wide applications to education. Animals have been used because of the rigid supervision and control to which they may be subjected, and the college student has been employed because of his convenience to psychological laboratories. More studies are needed which deal with children who range in ages from the kindergarten stage through the adolescent period. When this need is met, data regarding the learning process will be more adequately established.

Animal experimentation has made distinct contributions in the fields of biology, medical science and nutrition. Knowledge relative to the adequacy and value of vitamins and various types of diet has been established on the basis of results obtained in animal laboratories. In the field of educational psychology, a study of animals has been the basis for establishing the methods and laws of learning, and in some instances it would appear that animals exhibit many characteristics which are common to human learning activities. Studies with animals have also furnished inferences where direct application was not feasible. If purpose and flexibility are noted in the learning of

animals, the assumption is that human beings will demonstrate these traits to a greater degree. In the chapters which follow, the results of animal experimentation are used in the discussion of problems when human experimentation is lacking or limited. Preference is given to those studies, when available, in which human beings have been employed as subjects. It is obvious that in some phases of educational psychology animal experimentation has made greater contributions than in others. In some of the neurological and physiological interpretations of learning, principles have been developed primarily on the basis of animal investigations. Animal experimentation may provide the foundation for the study of learning, but human experimentation must supply the structure.

D. Summary

The field of educational psychology from the standpoint of scientific development owes its inception to the classical works of Ebbinghaus and Meumann of Germany and Thorndike in the United States. The field has grown rapidly in both techniques and results until at the present there is a large body of objective literature. The chief purpose of educational psychology is to discover facts and principles which relate to the improvement of learning efficiency.

Educational psychology from the viewpoint of teaching aims: (1) to develop an understanding and appreciation of the factors of heredity and environment which underlie learning ability; (2) to provide bases for understanding the nature and principles of learning and to supply the technique for its improvement; (3) to develop ability in the recognition of the different types of learning and in the application of these types to various fields of subject matter; (4) to understand and appreciate factors influencing individual ability to learn; (5) to provide understanding and ability in the recognition of the external factors which are largely within the control of the teacher and school; (6) to provide skill in the methods of measuring achievement and in evaluating teaching efficiency; and (7) to develop an appreciation of the individual. Educational

psychology in general aims: (1) to provide a body of facts and methods which can be used in solving teaching problems; (2) to develop the scientific and problem-solving attitude; and (3) to train in thinking psychologically about educational problems.

Experimental and descriptive methods are chiefly used in studying problems in educational psychology. An experiment is a procedure in which observation is controlled because of the control of the factors of time and complexity of conditions. The descriptive method studies facts and conditions as such with little control over the phenomena observed.

Educational psychology, in addition to the direct contributions in the fields of education and psychology, uses data from many fields. The aim of this book is to integrate and evaluate significant objective contributions from such sources.

CHAPTER II

THE BASES OF IMPROVEMENT

The school is interested in the ability of pupils to improve and in supplying the means for producing that improvement. Pupils incapable of some improvement are rarely found in school, but there are wide individual differences in ability to profit by training, and these complicate the problems of the school because provision must be made for them. Both heredity and environment have definitely established their influence upon the child before his formal education begins. The question is not whether either hereditary or environmental factors alone can account for improvement, but the extent to which each influences the success of the pupil and how each may be used in furthering the economy of learning.

A. Heredity and Environment

The term heredity refers to the reproduction and transmission of ancestral traits, while environment includes all of those external factors and conditions which actively influence the development of the individual. Educational psychology is primarily interested in the inheritance and development of mental and educational traits and is only indirectly concerned with those of physical traits. However, the inheritance of mental and educational traits appears to conform to the laws and principles of biological heredity. Heredity furnishes the ability to improve and environment supplies the opportunities, methods and incentives. The two terms are in each case names for an indefinite number of different factors and so far no means has as yet been devised which will definitely separate and measure their influences.

1. **Earlier Studies.**—The earlier studies on heredity dealt chiefly with the transmission of traits both through one and

through several generations and with relatively select groups. Studies were made of those groups which represented the highest or the lowest types of the population. The former group is illustrated by the study of social, mental and moral heredity of famous families, while the latter is exemplified by investigations dealing with feeble-minded and degenerate families. These early studies were largely historical and descriptive investigations and consisted chiefly in noting the frequency with which certain traits in families appeared in their descendants. Galton[1] made studies of eminent men and their relatives in an effort to determine whether natural ability was hereditary and to what extent it was transmitted. He used the frequency with which illustrious men had illustrious relatives as a method of proving ability hereditary. His later studies with similar twins reared apart and dissimilar twins reared together yielded results which led him to conclude that heredity was more important than environment in determining and shaping men's intellects.

Woods[2] made a study of more than 600 interrelated individuals of various countries of Europe beginning with the sixteenth century and determined resemblances for different degrees of blood relationship in order to ascertain the part played by heredity in the formation of mental and moral qualities. From the results of his studies he concluded that heredity was a major cause of such similarities.

Dugdale[3] and Estabrook[4] in a study of the Jukes family furnish examples of similar methods of study in which the traits of degenerate families were traced through several generations. Dugdale, who studied the Jukes family between 1875 and 1877, obtained his data from civic, social and criminal records and personal interviews in order to determine the characteristics

[1] GALTON, F., *Hereditary Genius*, New York, Macmillan, 1914.

GALTON, F., *Inquiries into the Human Faculty and Its Development*, New York, Dutton, 1908.

[2] WOODS, F. A., *Mental and Moral Heredity in Royalty*, New York, Holt, 1906.

[3] DUGDALE, R. L., *The Jukes*, New York, Putnam, 1877.

[4] ESTABROOK, A. H., *The Jukes in 1915*, Washington, Carnegie Institute, 1916.

of the members studied. Estabrook, who continued the study of this family during the years 1912 to 1915, describes the results of both studies as follows:

Dugdale studied 709 persons, 540 being of Juke blood and 169 of "X" blood who had married into the Juke family. He estimated that the Juke family would consist of 1200 persons were it possible to have traced all the lines of descent from the original 6 sisters. Of the 709 whom he studied, 180 had either been in the poorhouse or received outdoor relief to the extent of 800 years. There had been 140 criminals and offenders, 60 habitual thieves, 7 lives sacrificed by murder, 50 common prostitutes, 50 women venereally diseased contaminating 440 persons, and 30 prosecutions in bastardy. The total cost to the state of New York of this one group of mental and social degenerates was estimated, for a period of 75 years beginning in 1800, at $1,308,000.

In the present investigation, 2820 people have been studied, inclusive of all considered by Dugdale; 2094 were of Juke blood and 726 of "X" blood who married into the Juke family; of these 366 were paupers, while 171 were criminals; and 10 lives have been sacrificed by murder. In school work 62 did well, 288 fairly well, while 458 were retarded two or more years. It is known that 166 never attended school; the school data for the rest of the family were unobtainable. There were 282 intemperate and 277 harlots. The total cost to the state had been estimated at $2,093,685.

Pearson's investigations represent a different approach to the study of heredity, and were perhaps the first attempts at objective measurement. His studies also differed from those preceding in that they involved typical children instead of the extremes of the population. He made extensive studies of both mental and physical characteristics of brothers and sisters and correlated the results of his measurements. The results[1] obtained for approximately 2,000 pairs of brothers and sisters are shown in Table 1.

Pearson found a significant relationship between brothers and sisters, and, since unrelated children usually show a coefficient of about zero, he concluded that heredity was the more important factor contributing toward such relationship.

[1] PEARSON, K., On the laws of inheritance in man: on the inheritance of the mental and moral characters in man, *Biometrika*, 1904, 3, 131–190.

TABLE 1.—INHERITANCE OF MENTAL CHARACTERS: CORRELATIONS*
(After Pearson, 1904)

Character	Brothers	Sisters	Brother-sister
Vivacity	0.47	0.43	0.49
Assertiveness	0.53	0.44	0.52
Introspection	0.59	0.47	0.63
Popularity	0.50	0.57	0.49
Conscientiousness	0.59	0.64	0.63
Temper	0.51	0.49	0.51
Ability	0.46	0.47	0.44
Handwriting	0.53	0.56	0.48
Mean	0.52	0.51	0.52

* Correlation refers to the relationship between two traits and is expressed numerically from minus 1 to plus 1. When it is considered that zero means no relationship whatever and any number between zero and plus 1 indicates a certain degree of positive relationship, these numbers assume meaning.

Whether the early investigations dealt with groups of famous families or those of the lower intellectual strata or typical children, the general opinion was that heredity and not environment was the controlling factor in behavior. Since good heredity is usually associated with good environment and poor heredity with poor environment, many of these early studies were only indicative of tendencies and did not differentiate between their influences. Whatever could not be explained readily by the forces of environment was attributed to those of heredity. The measurement of success or failure of families was largely determined by social or professional status in the case of famous families and criminal records and conditions of poverty in those of low economic and social strata. Under the condition of these studies there was little possibility for distinguishing between heredity and environment and for controlling the factors which influence their manifestation. Indeed, one may use these early investigations as an argument that favorable environment rather than heredity produces successful descendants in one case and unsuccessful descendants in another.

2. Recent Studies.—The development of intelligence and educational tests and their application to the problems of

heredity and environment have made possible new lines of investigation, the results of which have supplemented to a considerable degree the findings of the earlier studies. Although these tests have limitations, they furnish the most accurate and objective measurement so far devised and aid in the description of individual differences. Objective instruments have made possible more accurate measurement of traits, and statistical devices have enabled investigators to describe and interpret more precisely the results of measurement. These studies have dealt with a single generation and the results have been interpreted by means of the correlation device. Intelligence tests have been most frequently used for the determination of hereditary influences while educational tests have been employed to measure the influences of environment.

The procedure generally followed is (1) to hold heredity constant and vary environment, or (2) to hold environment constant and vary heredity. Investigators assume that heredity is constant when children have the same parents, and environment is considered constant when children of the same or different parents are reared under closely similar conditions. It should be understood that the term constant is used in a relative sense only and it is probable that, even though children have the same parents, heredity may not be constant. In the following discussion attention will be directed to three types of investigations which have attempted to determine the influences of heredity and environment. These investigations include studies of twins, orphanage children and foster children.

a. Studies of Twins.—The majority of recent studies on heredity have dealt with siblings.[1] Brothers and sisters have closer similarity in both heredity and environment than cousins or unrelated children. We are beginning to realize, however, that children of the same parents reared in the same home are subject to different environmental influences due to age, sex and family relationships, while children born at different stages in the lives of the same parents may have different hereditary influences owing to differences in age and physical condition

[1] The term *siblings* refers to children born of the same parents.

of the parents. Because twins represent the nearest approach to identical heredity it is believed that intensive study of their various traits will throw much light upon the problem of heredity.

Identical twins, produced from the same egg cell and fertilized by the same sperm cell, should have the same chromosomal equipment and their heredity should be identical. Consequently any differences found between identical twins would be due to the influences of environment. Fraternal twins, originating from different egg cells and fertilized by different sperm cells, afford opportunity for wider differences than identical twins, and such differences may be attributed to both heredity and environment. Identical twins, therefore, afford the nearest approach to constant heredity. Although it is difficult to distinguish between identical and fraternal twins, Newman seems to have developed accurate and practicable methods for their differentiation.

Thorndike[1] was one of the first to study the intellectual and educational traits of twins. His assumption was that, if the resemblance between twins was due to heredity, there would be a closer relationship between twins than siblings, that this relationship would remain constant with age, and that the resemblance would be the same for tests which measure educational traits subject to training and those which measure the fairly constant traits of intelligence. On the other hand, if environment is the controlling factor, the resemblance between twins should increase with age, be equal to that of siblings, and be closest in educational traits which are influenced by training. Thorndike's results did not confirm the assumptions that he made at the outset of his study but he concluded from the correlations found that heredity is the more important factor in causing the resemblances. However, since older twins are found to be less alike than younger twins, it may be assumed that environment is an important factor in causing such differ-

[1] THORNDIKE, E. L., Measurements of twins, *Arch. Phil., Psychol. & Scient.*

ences, as there is likelihood that their environment will have become increasingly dissimilar.

Averill and Mueller,[1] from physical and mental measurements of 10 pairs of fraternal twins, conclude that two contemporaneous individuals, whether identical in appearance or not, will, on the average, bear a closer resemblance in both physical and mental characteristics than any other noncontemporaneous individuals in the same family. Where there is identity of appearance the chances are even greater for similarities in other traits.

Lauterbach[2] studied 210 pairs of twins on the basis of 21 physical and mental measurements, some of the results of which are shown in Table 2. He found no greater resemblance between younger twins than older, but he did discover that twins of the same sex have a greater degree of similarity than

TABLE 2.—COEFFICIENTS OF CORRELATION FOR TWINS OF THE SAME AND DIFFERENT SEXES

(After Lauterbach, 1925)

	Same sex	Different sex
I.Q.	0.77	0.56
Reading quotient	0.59	0.56
Arithmetic, accuracy	0.69	0.35
Arithmetic, speed	0.70	0.39
Memory for digits	0.40	0.25
Handwriting, quality	0.69	0.37
Handwriting, speed	0.83	0.41
Averages	0.67	0.41
Cephalic index	0.67	0.59
Weight	0.89	0.50
Height, standing	0.80	0.53
Height, sitting	0.73	0.59
Averages	0.77	0.55

those of different sexes. Twins of different sex have about the same degree of resemblance as do other brothers and sisters, while twins of the same sex have a much closer degree of likeness. From the results of his studies he concludes that heredity,

[1] AVERILL, L. A., and A. D. MUELLER, Physical and mental measurements of fraternal twins, *Ped. Sem.*, 1925, **32**, 612–628.

[2] LAUTERBACH, C. E., Studies in twin-resemblances, *Genetics*, 1925, **10**, 525–568.

rather than environment, has the greater influence in determining the resemblance.

Wingfield[1] administered intelligence and educational tests to 102 pairs of twins. He attempted to eliminate misinterpretations found in previous studies by accounting for the effect of age upon the amount of resemblance, and also took into consideration the variability of his measurements. His results are significant because they are based upon intellectual traits, which are supposed to be relatively innate, and achievement in various school subjects which is dependent primarily upon training.

TABLE 3
(After Wingfield, 1928)
1. Resemblance of Twins in General Intelligence

Group	No. of pairs	Raw r	r for constant age	S.D.	S.E. of estimate	M. dif. in I.Q.
All twin pairs	102	0.76	0.75 ± 0.029	13.5	8.92	9.65
Unlike sex pairs	26	0.62	0.59 ± 0.086	12.9	10.40	12.00
Like sex pairs	76	0.83	0.82 ± 0.025	13.6	7.79	8.50
Fraternal pairs	57	0.72	0.70 ± 0.045	12.6	9.03	11.74
Identical pairs	45	0.91	0.90 ± 0.019	14.3	6.23	6.23

2. Resemblance of Younger Twins (45 Pairs) and Older Twins (50 Pairs)

Twins	Twins 8 to 11 years			Twins 12 to 15 years		
	Raw r	r for constant age	S.E. of estimate	Raw r	r for constant age	S.E. of estimate
General intelligence (I.Q.)	0.73	0.71 ± 0.047	8.09	0.78	0.77 ± 0.038	9.16
Stanford achievement E.Q.	0.73	0.64 ± 0.060	8.13	0.90	0.87 ± 0.023	5.35
Stanford achievement A.Q.	0.82	0.82 ± 0.033	3.95	0.72	0.72 ± 0.046	5.10
Arithmetic	0.94	0.89 ± 0.022	2.70	0.85	0.73 ± 0.045	4.00
Spelling	0.89	0.85 ± 0.029	4.18	0.89	0.85 ± 0.026	4.41
Average	....	0.742	5.41	....	0.788	5.60

Wingfield's results agree in the main with those of Lauterbach. He believes it erroneous to conclude that environment could

[1] WINGFIELD, A. H., *Twins and Orphans: The Inheritance of Intelligence*, London, J. M. Dent, 1928.

possibly account for the intellectual and educational resemblances. McNemar,[1] in his study of 46 fraternal and 47 identical pairs of male twins of junior-high-school age, found that resemblance in several acts of motor skills was approximately the same as that of anthropometric measurements. On the basis of his results he concluded that heredity is the most plausible explanation for individual differences in acquisition of motor skills.

The investigations dealing with twins point toward definite conclusions. Identical twins show the closest resemblance in physical and mental traits. Fraternal twins of the same sex rank next in order while those of different sexes show the least resemblance and are not much, if any, more alike than other brothers and sisters. Twins considered as a group show a much higher degree of similarity than do ordinary siblings. The average coefficients of correlation for siblings range from 0.30 to 0.50 while those for twins vary from 0.60 to 0.90. The implication is that the greater the degree of identical heredity, the closer the resemblance. As some of the studies have indicated, the younger the twins, the greater the likeness. The results of these studies show that heredity makes for similarity while environment makes for differences. Since environment is likely to be relatively constant for twins during infancy and early childhood and becomes increasingly less similar with age, owing to its accompanying diversity of interests and activities, data are needed for the same twins over a period of years. Although studies of twins reared under similar and dissimilar environments have uniformly appeared to show that heredity and not environment is the important factor causing resemblances of twins, they have only demonstrated the variability of heredity and suggested new problems for further investigation.

b. Studies of Orphanage Children.—Since it is the policy of most orphanages to keep children of the same families together, nowhere is there better opportunity to study the relative effects

[1] McNemar, Quinn, Twin resemblance in motor skills and the effect of practice thereon, *Ped. Sem.*, 1933, 42, 70–99.

of heredity and environment. Pearson[1] has observed that the orphanage is an excellent place to study such relationship since it furnishes a relatively uniform environment in both the nurture and training of children. Similar observations have been made by Gordon,[2] Jones and Carr-Saunders.[3] Studies of related and unrelated orphanage children reared together for varying periods furnish data of the sort suggested by Pearson. Public-school children on the other hand may be said to represent an environment which is relatively less controlled than that of an orphanage and may, therefore, be used as a basis of comparison. We may determine the degree of relationship between brothers and sisters who have been reared for an appreciable length of time in institutions and compare it with that of brothers and sisters who have been reared in private homes and attend public schools. We may further compare the relationship of unrelated children who have been reared in orphanages with related orphanage children, as well as with unrelated children reared in homes. If environment is a determining factor we should expect to find greater resemblance between brothers and sisters who have been reared in orphanage institutions than between brothers and sisters reared in homes and attending public school. As a necessary corollary we should also expect unrelated orphanage children to show greater homogeneity as their length of residence in an orphanage increased.

Gordon[4] appears to have been the first to study orphanage children in this country. In addition to studying the intellectual status of orphanage children in California, she made two studies which dealt with the effectiveness of heredity and environment on intelligence. She used the Stanford Revision test and her method was to determine coefficients of correlation between brothers and sisters in terms of intelligence quotients.

[1] PEARSON, K., *Biometrika*, 1918, 10.

[2] GORDON, KATE, Psychological tests of orphan children, *J. Delinq.*, 1919, 4, 1–52.

[3] JONES, D. C. and A. M. CARR-SAUNDERS, Relation between intelligence and social status among orphan children, *Brit. J. Psychol.*, 1927, 17, 343–364.

[4] GORDON, *op. cit.*

She also used brothers and sisters who were reared in homes and attended the same public school as a basis of comparison. If there were data available for three in a family, those for the youngest child were omitted; but if there were data available for four in a family, those for two pairs were kept, the younger being paired with the next older. In all cases excess siblings were omitted. Using this method she computed correlations by the Pearson formula and in one study based upon 91 pairs found a coefficient of 0.53, which she considered significant because unrelated children paired at random usually yield a coefficient of zero. Using the same brothers and sisters and adding 125 others, she obtained in another study[1] a coefficient of 0.61.

From Gordon's data one may conclude that siblings after a period of residence in an orphanage are not more alike than siblings reared in homes and attending the same public school. From her studies she contends that heredity is more important than environment in causing resemblances between siblings. Gordon's studies are important not only because they were the first attempts to study the intellectual resemblance of orphanage siblings, but also because they served to establish methods of study which have been used by other investigators with larger groups and different tests.

The results obtained from another study[2] of the intellectual resemblance between pairs of orphanage siblings and random pairings of unrelated orphanage children, together with similar computations for public-school siblings, show a wide range of coefficients. The average for orphanage siblings is approximately 0.41, which may be considered as typical of siblings in orphanages. The coefficients are somewhat lower than those found by Gordon, but the numbers are considerably larger and different tests were used. The coefficients for unrelated orphanage children cluster around zero as might be expected in

[1] GORDON, KATE, Influence of heredity on mental ability, Report of the children's department, State Board of Control of Cal., 1918–1920.

[2] DAVIS, ROBERT A., The influence of heredity on the mentality of orphan children, *Brit. J. Psychol.*, 1928, **19**, 44–59.

pairing unrelated children at random. The data for public-school brothers and sisters are in marked agreement with those obtained by Gordon, who shows that orphanage children who have been in institutions for several years are not more alike than children who are reared in homes. Unrelated public-school children as in the case of unrelated orphanage children show coefficients of about zero.

The facts do not indicate that institutional life provided by an orphan home has any effect in causing orphanage siblings to resemble each other any more closely than public-school children who have been reared in homes. When brothers and sisters have been reared in an orphanage for a considerable length of time, there appears no evidence that a difference has been produced. As Table 4 indicates, orphanage siblings reared together from less than one to three years show an average coefficient of about 0.49; those who have been reared together from four to six years show an average coefficient of about 0.29; and those reared together from seven to nine years have an average coefficient of 0.50. When unrelated orphanage children have been reared together for varying periods of time, the coefficients are approximately zero and in many cases they are negative.

An orphanage institution supplies as nearly uniform an environment as is possible under existing social conditions and references applicable to home environment do not apply with equal force to institutional life. Watson[1] who emphasizes the environmental point of view says:

> Fathers and mothers cannot react to two children alike; they cannot treat the second child as they treat the first born. Identical twins almost indistinguishable by sight and voice come nearest to having the same environment. Unless an accident occurs to one and not to the other they will show closely similar behavior. But if the children are separated at an early age and brought up in widely different homes their organization is widely different. The same environment, but different traits, breaks down because there is no such thing as same environment.

[1] WATSON, J. B., The behaviorist looks at instincts, *Harper's Magazine*, July, 1927.

TABLE 4

1. Effect of institutional life on mental relationship of orphanage children

Years in home, inclusive		r	Mean dif.	No. of pairs
Siblings reared together in orphanages:				
0 to 3	D.	0.511 ± 0.041	12.31	147
	H.	0.488 ± 0.042	15.35	147
4 to 6	D.	0.343 ± 0.065	11.90	82
	H.	0.238 ± 0.070	15.75	82
7 to 9	D.	0.476 ± 0.070	12.15	54
	H.	0.542 ± 0.065	14.94	54
Unrelated children reared together in orphanages:				
0 to 3	D.	0.062 ± 0.054	18.25	147
	H.	0.041 ± 0.055	22.29	147
4 to 6	D.	0.075 ± 0.074	14.26	82
	H.	0.016 ± 0.075	20.48	82
7 to 9	D.	0.065 ± 0.090	15.48	54
	H.	0.044 ± 0.091	17.35	54

2. Mean I.Q.'s and standard deviations, together with mean chronological ages

Years, inclusive		I.Q.	S.D.	No. of cases	Mean chronological ages
Siblings reared together in orphanages:					
0 to 3	D.	86.39	15.30	294	12–7
	H.	87.36	17.60	294	12–7
4 to 6	D.	86.40	12.65	164	13–6
	H.	88.30	15.80	164	13–6
7 to 9	D.	85.95	15.60	108	14–5
	H.	86.02	19.05	108	14–5
Unrelated children reared in orphanages:					
0 to 3	D.	86.05	15.30	294	12–8
	H.	86.65	19.70	294	12–8
4 to 6	D.	84.02	12.90	164	13–5
	H.	87.25	17.15	164	13–5
7 to 9	D.	84.59	13.60	108	14–4
	H.	84.86	16.05	108	14–4

D. = Dearborn; H. = Haggerty.

This statement, emphasizing as it does the importance of environment, suggests that children subjected to common environments tend to resemble one another more closely as the duration of similar environments increases. The second implication relates to the age at which environment begins to influence most forcefully the conduct of children, the theory being that during the first few years of a child's life he is most susceptible to impression.

Data which deal with the effect of age of entrance upon mental relationship of related and unrelated orphanage children set forth figures of but slight quantitative value. It was thought that by holding the period of orphanage residence constant the factors affecting intelligence would be reduced to the single variable of age of entrance. It was further believed that, if institutional life had any effect upon mental relationship of related and unrelated orphanage children, it would be made manifest in the case of those children who had entered while very young and who had been reared for a considerable period of time in orphanage institutions. A further statement by Watson[1] has its bearing on this phase of the problem. He states:

> The behaviorist cannot doubt that the first two years of infancy are enormously important in shaping the child. . . . By the end of his second year the child's temper is well organized; his vocational slants, his character, his fears, his positive bent toward things . . . has been so slanted that only a divine being could unmake him and give him over to a biologist as new material fit to watch for the unfolding of family traits.

The facts which show the relationship for related and unrelated children who entered orphanages at various ages take this factor into account although the differences are usually so small as to be of doubtful value.

Wingfield[2] has studied the relationship of orphanage children by means of both educational and intelligence tests. Since performance in school subjects is more susceptible to training than traits of intelligence which presumably are innate, his

[1] *Ibid.*

[2] WINGFIELD, *op. cit.*

results are significant. The orphans studied by Wingfield had spent a minimum of three or more years in the same institution. Some of his results are presented in Table 5.

TABLE 5
(After Wingfield, 1928)
1. Orphans paired at random (15 pairs)

Traits	Raw r	Correlation between age and trait	r for constant age
I.Q.'s	−0.49	−0.18	−0.54
E.Q.'s	−0.19	−0.62	−0 79
A.Q.'s	−0.54	−0.38	−0.79
Arithmetic	0.14	0.58	−0.30
Spelling	0.08	0.61	−0.49
Average	.....	......	−0.58

2. Orphans paired to nearest age (15 pairs)

Traits	Raw r	Correlation between age and trait	r for constant age
I.Q.'s	0.16	−0.18	0.13
E.Q.'s	0.34	−0.62	−0.07
A.Q.'s	0.54	−0.38	0.47
Arithmetic	0.46	0.58	0 18
Spelling	0.59	0.61	0.35
Average	....	......	0.21

Wingfield's data also indicate that orphans who have spent a considerable part of their lives in the same institution are no more alike than unrelated children who are paired at random. The results from the measurement of educational traits do not seem to be any more influenced by environment than traits of intelligence.

Investigations dealing with the intellectual and educational resemblance of orphanage children indicate that brothers and

sisters who are reared in orphanages for varying lengths of time are not affected in their resemblance to one another. Brothers and sisters who have been reared together in the same environment for a long period of years do not resemble one another any more closely than do those who have been reared together for a short period. Rearing unrelated children together in the same environment does not make for greater homogeneity in mental and educational traits. It seems that equalized opportunity as found in institutional life for varying lengths of time does not reduce original likeness within families or differences between families. The resemblances found throughout the studies of orphanage children appear to be innate rather than environmental.

c. Studies of Foster Children.—Studies of foster children furnish data which closely resemble those obtained from orphans. A study by Freeman[1] indicates that foster children on the average have a poor inheritance. The fact that it is necessary for parents to have their children adopted indicates a lack of economic and social efficiency, suggesting among other things that the general intellectual status of the parents is low. It may also be assumed that the environments of the parents of foster children are usually poor and that foster children before adoption are handicapped on an intelligence test because of their poor environment as well as their poor heredity.

Because dependent children are as a rule adopted by families of a certain amount of economic and social efficiency, the family environments of foster children after adoption are usually much superior to those of their own families. If environment is an important factor, then it may be expected that the average intelligence quotient of adopted children in their improved environment would be appreciably higher than that of other

[1] FREEMAN, F. N., The effect of environment on intelligence, *School & Soc.*, 1930, 31, 623–632.

BURKS, B. S., The relative influence of nature and nurture upon mental development; a comparative study of foster-parent-foster-child resemblance and true-parent-true-child resemblance, twenty-seventh Year Book, *Nat. Soc. Study Educ.*, 1928, Part 1.

children of similar origin in their original environment. Freeman finds that the average intelligence quotient of 401 foster children is 97.5, which indicates that those children are practically identical with children from the average population.

Further relationship, in addition to comparing foster children with children in general, was shown by comparing the intelligence of children who are adopted into good homes with those whose adopted homes are relatively poor, the inference being that if environment is the determining influence those children who were taken into good homes would have higher intelligence scores than those adopted into poor homes. The children were also classified on the basis of illegitimate and legitimate groups. The average intelligence quotient of legitimate children who were placed in good homes was 101 and in poor homes 89. For the illegitimate group the difference between the foster children in the good and poor homes was even greater. In order to determine the influence of age upon entrance to foster homes, these children were classified on the basis of those adopted before five years of age and those after five years. The average intelligence quotient of those who were adopted early was 96 and those who were adopted later 88.

In order to eliminate variable factors as far as possible, Freeman obtained 125 pairs of brothers and sisters from the foster children group and made comparisons on the basis of those brothers and sisters who were adopted by good homes and those adopted by poor homes. The member of each pair who was adopted by a good home was placed in one group, and the other member of the pair adopted by a poor home was assigned to the other group. The average intelligence quotient of those siblings adopted by the better homes was 95 as compared with 86 for their own brothers and sisters in the poorer homes. Differences were further brought out when these siblings were classified according to the age at which they were adopted. The average intelligence quotient of those who were placed at an early age was 94.3 as compared with 86.4 for those who were placed at a later age. Further evidence of the effect of good home environment on these foster children is the improve-

ment that they make in school. Similar results have been found by Klineberg.[1]

3. Evaluation of Heredity and Environment.—The preceding data have shown two conflicting lines of evidence. On the one hand there are the data derived from a study of twins and orphanage children which have tended to show the relatively great influence of heredity, and on the other hand the studies of foster children which have tended to show the influence of environment on intelligence. In the two types of studies, we have dealt with two distinct types of environment—orphanages and homes. The orphanage represents an environment which is relatively constant in so far as the nurture and training of the children are concerned, but it still is questionable whether it is the type of environment to stimulate the best expression of personality. Both orphanage and foster children are similar in intellectual status, the average intelligence quotient for both groups being about 85. That is, the two groups are about equal before foster children have been subjected to better home environment.

No attempt has been made in the case of orphan children to determine whether their intelligence is lowered or raised as a result of institutional residence. Such an investigation would make valuable data for comparison with that of foster children. An experiment which is now gaining the attention of some of those in charge of orphanages is the segregation of the children into smaller units or the so-called "cottage or home plan." It is believed that orphanage children would receive greater foster care and be allowed greater individual expression if they were placed in smaller units where at least an attempt would be made to approximate the home atmosphere. It is questionable whether institutional life tends to make for homogeneity of thought, feeling and action. This question cannot be answered entirely from a study of mental traits, but the method employed in the study of the effect of institutional life could be used in the measurement of other traits.

[1] KLINEBERG, OTTO and LITHHAUER, A study of the variation in I.Q. of a group of dependent children in institution and in foster home, *Ped. Sem.*, 1933,

One fact stands out from the investigations dealing with the similarities of related children. Heredity, contrary to what we have usually thought, is not a constant and invariable factor but an extremely variable one. Unrelated children show a correlation coefficient of zero, siblings about 0.40 or 0.50, and twins about 0.75. A part of this condition may be explained by the work of Galton who found that there are two opposing tendencies in individuals—one to deviate from the average or central tendency of the race, the other to regress toward the central tendency, the combination of the two resulting in a compromise. In a family of infinite size, the relationship would, as in the case of unrelated children, cluster around zero.

The degree of importance attached to the investigations dealing with mental traits depends a great deal upon the confidence reposed in intelligence tests. There are some who hold that intelligence tests, by their very nature, are measures of both innate ability and training. The differences between social groups can in many instances be explained by the relative lack of educational opportunity. It is well known that the intelligence quotient is only relatively constant. The average fluctuation of an intelligence quotient is about five points, and, as has been suggested, it depends upon one's point of view whether one calls this constancy or variability. The relative constancy of the intelligence quotient has formed the basis for much of our thinking that ability is fixed by heredity and that environment is a negligible factor. If environment does not affect intelligence itself, it is obvious that it does influence the expression of intelligence.

Recent experimentation by Jennings[1] indicates that environmental influences have a marked effect upon certain physical traits such as height and weight, and he suggests that physical growth is produced by the combined effects of heredity and environment. Nutrition, exercise, sunshine and rest exert a significant effect in determining the individual's physical

[1] JENNINGS, H. S., *Biological Basis of Human Nature*, New York, Norton, 1930.

development. If influences of environment are important in determining physical traits, it is likely that intellectual traits are even more significantly affected.

Although the majority of studies in recent years have dealt with mental traits, it must be borne in mind that intelligence is only one of several traits of the individual. It is probable that one's emotional, social and moral traits would be more directly affected by controlled living conditions than traits of intelligence. Available data suggest that resourcefulness,[1] initiative, self-reliance and character are influenced appreciably by environmental conditions, not to mention habits, ideals and attitudes.

To accept the extreme position of the hereditarian would make education largely deterministic. The individual is born with certain possibilities and limitations and education can provide only a few facts and skills. If one accepts the environmental point of view, success is determined largely by the improvement of environment. Both teachers and parents have a supreme responsibility in guiding the first few years of a child's life which are most important for the development of habits and skills. According to this point of view training of the child must be emphasized at an early age, the implication being that later attempts toward training and development are in the main unsuccessful. The environmental school of thought would further place the teacher in an unusually critical position in that emphasis must be placed on the provision of stimuli in the forms of techniques, methods and devices and improvement must be effected through them.

The extreme positions of the hereditarians and environmentalists are equally untrue to the facts. Whether education may improve the child's innate ability or not will depend a great deal upon the type of education to which the child is subjected. If it is conceived as a narrow or specific type, then the individual's possibility for growth and development will be limited. In so far as education is conceived in the broader

[1] HARRELL, MARGARET T., and ROBERT A. DAVIS, The effect of institutional life on character traits, *J. Abn. & Soc. Psychol.*, 1929, 24, 330–341.

sense and gives opportunity for the generalization of ideas,[1] then the possibilities for improvement and transfer are increased.

B. Theories of Improvement

The preceding discussion leads to a consideration of the nature of improvement. Three theories have been advanced as possible explanations: (1) the theory of improvable capacities and mechanisms; (2) the theory of stimulated growth; and (3) the theory of acquired specific techniques and knowledge.

1. The Theory of Improvable Capacities and Mechanisms.—Proponents of this theory maintain that improvement in learning may be based upon changes made in the capacities or neural mechanisms of the learner. Since practice in physical activities tends to increase skill, it is believed that the same principle operates in mental activities. For example, as a result of practice improvement may be made in memory, reasoning and attention as well as the neural mechanism as a whole. As Gates[2] points out,

> The older faculty theory, which assumed that memory, perception, retentiveness were improved in general by practice in some particular type of training which involved the general power, has been modified, usually in the face of the facts yielded by the transfer of training, but the newer views differing only in degrees are still defended and defensible.

The mental function which has probably received the greatest attention is memory, but most investigators do not make any distinction between improvement in memory itself and improvement in the methods of memorizing. One of the first attempts to distinguish clearly between the influences of practice on memory and improvement in methods of memorizing was made by Smith and McDougall.[3] They assumed that if improvement in learning is proportional to that in relearning, the improvement in each case is due to improved methods of learning, but if there is greater improvement in relearning than

[1] Freeman, *op. cit.*

[2] Gates, A. I., and Grace A. Taylor, An experimental study of the nature of improvement resulting from practice in a mental function, *J. Educ. Psychol.*, 1925, **16**, 583–592.

[3] Smith, May, and W. McDougall, Some experiments in learning and retention, *Brit. J. Psychol.*, 1920, **10**, 199–209.

in learning, improvement is due to the increased power of retention. Daily practice was given for a period of 6 months in the case of five subjects and 12 months in the case of one. The method consisted in learning a group of syllables and in relearning the same group 24 hours afterwards. The results are presented in Table 6 which shows the average number of repetitions for learning and relearning syllables at definite periods.

TABLE 6.—EFFECT OF PRACTICE UPON RETENTION
(From Smith and McDougall, 1920)

Subjects	Average of 8 exps., of repetitions for learning at beginning	Average of 8 exps., giving number of repetitions for learning 6 mo. after		Average no. of repetitions to relearn at beginning	Average no. of repetitions to relearn 6 mo. after	
		Number	Gain, per cent		Number	Gain, per cent
A	14	8	43	7	4	43
B	16	9.6	40	5.6	3	47
C	8	7	....	3	3	
D	9	5.6	38	2.8	1.2	57
E	13	11	15	9	6	33⅓
F	12	8	33⅓	6	4	33⅓

The findings of this experiment are only suggestive and do not offer definite evidence in either direction, although it would appear that practice aided some individuals to relearn that which had been learned. Advocates of the theory of improvable capacities are usually those who believe that intelligence and learning ability can be modified by the forces of environment.

2. The Theory of Stimulated Growth.—This theory, which was recently revived by Gates and others,[1] is based upon the assumption that, since mental capacities grow gradually under normal conditions from birth to maturity, it is conceivable that intensive practice preceding the limits of development might increase the rate of individual growth during the

[1] GATES and TAYLOR, *op. cit.*

formative period. If this assumption were true, the influence of early training and environment would be of particular significance to education. It follows that any valuable evidence in testing this assumption would necessarily have to be based upon a study of young children. A study has been reported by Gates[1] who investigated "systematic and opportunistic methods" of teaching in the first grade. Two groups of children equal in scholastic maturity, age, subject matter and skill were studied. In one group the children were taught by a systematic method of teaching and in the other the inclinations of the children were followed. The results indicated that intensive training did not increase the general capacities of the children but that improvement was due to the acquisition of better methods of study.

Gesell and Thompson[2] performed an experimental study by the method of co-twin control to determine the influence of special training upon two fields of behavior. Twin T at the age of 46 weeks was subjected to a schedule of daily training in climbing and cube behavior for a period of six weeks while Twin C was used as control and deprived of all specific training in these reactions. As a check upon the experiment, Twin C at the age of 53 weeks was subjected to a brief period of training in climbing extending over a two-week period. These writers find that there is no evidence to support the theory that special training will hasten the appearance of the reactions studied and that the time of their appearance is determined chiefly by the maturity of neural structures; and that, although function enters into growth, training does not transcend maturation. These results are in general confirmed by McGraw,[3] who found that the developmental level achieved by negro infants was about 80 per cent as mature as that of white babies of similar age.

[1] GATES, A. I., Experimental investigations of learning in the case of young children, *J. Educ. Res.*, 1925, 12, 41–48.

[2] GESELL, ARNOLD, and HELEN THOMPSON, Learning and growth of identical infant twins: an experimental study by the method of co-twin control, *Genet. Psychol. Monog.*, 1929, 6, No. 1.

[3] MCGRAW, MYRTLE, B., A comparative study of a group of Southern white and negro infants, *Genet. Psychol. Monog.*, 1931, 10, No. 1.

Since the study dealt with very young children when environmental factors are minimized, her results are significant.

3. The Theory of Acquired Specific Techniques and Knowledge.—This theory[1] postulates that an individual's improvement in any task may be attributed to the acquirement of techniques of studying and learning, rather than to improvement in capacities or to accelerated growth. Thus in learning any school subject, improvement is effected by better concentration on the task, by improved organization and adaptability of subject matter and by elimination of nonessential elements in the learning situation. The learner is believed to improve by acquiring the "tricks of the trade." This view of improvement is usually held by those who believe that innate ability is relatively invariable and that progress in school is induced by skillful methods of teaching and presentation of materials. Special classes composed of dull pupils, in which every effort is made to stimulate learning, afford excellent opportunity for the type of investigation which might be made to test the validity of this theory.

4. Evaluation of Theories of Improvement.—The theories of improvement afford opportunity for speculation but the first two have few experimental data from which to draw valid conclusions. The results of studies indicate that in the main progress is not affected by improvement in the capacities and neural mechanisms of the learner or by stimulated growth in traits before maturity, but by the acquirement of techniques of studying and learning. The function of the teacher is to aid pupils in the development of better techniques of study. It appears that the majority of pupils are capable of some improvement if properly guided in the learning situation. It is within the power of teachers to present materials and techniques which will aid the pupil in making himself.

C. The Interrelationship of Mental Functions

Interest in the relation between mental functions probably has its origin in the school of "faculty psychology" which was

[1] Gates and Taylor, *op. cit.*

formerly entrenched in psychological theory and widely applied to the field of education. The theory of "faculty psychology" held that the mind was made up of a number of psychological entities, and that, once these individual entities were discovered and trained, they would function equally well in all situations of life. This point of view had its basis in two equally false assumptions. The first assumption was based upon an obsolete physiological notion which held that within the brain there were different organs possessing specific functions. Within the brain there were seats of memory, reasoning, attention and perception. The other assumption, which was psychological in character, held that by specific training and practice the more general mental functions could be developed and trained. The first of these theories has been exploded as a result of increased knowledge of the nervous system, and, as has been indicated, the second does not have sufficient experimental evidence for its confirmation. Renewed emphasis has been given this question in recent years and the results of investigation have had far-reaching effect upon an understanding of the nature of learning ability and intelligence.

1. The Theory of Two Factors.—Spearman[1] maintains that success in any intellectual performance is dependent upon two major factors. The first is the general fund of mental energy or general intelligence which is usually designated as the *g* factor. It is presumably innate and constant for the same individual, but may vary widely in different individuals. Spearman believes that it may be measured in some degree by tests of general intelligence. The second factor represented by *s* is the specific ability to perform a particular kind of task. This specific ability not only varies in different individuals, but within the same individual. A high degree of *s* in ability to perform in one task does not insure an equal amount of ability to perform in other tasks.

The method employed by Spearman was to measure a large number of mental and educational abilities, including some

[1] Spearman, C., Manifold sub-theories of two factors, *Psychol. Rev.*, 1920, **27**, 159–172.

artificial tests, and to determine correlations and intercorrelations among them. The correlations computed tended to group themselves in hierarchical order. Since it was found that some of the abilities correlated significantly with each other, the conclusion was that the degree of relationship was conditioned by the presence of some general factor operating in all of them. Correlations between the more abstract abilities and some of the abilities involving motor skill were not significant, the theory holding that some concession should be made for specific abilities in which the specific factor element entered. The assumption is that unless an individual possesses a sufficient amount of general mental energy, the possibilities of attaining marked success in any field are limited. A corollary assumption which can be made from this theory is that given sufficient *g* and *s* potentiality, the individual can succeed in any task, provided interest, industry and application are maintained. A further conclusion might be deduced to the effect that individuals who appear to be proficient in special subjects and who demonstrate special ability, but who do not possess sufficient general capacity *g*, are never creative in their special fields of work.

The theory of two factors has elicited considerable discussion both in this country and in England and has been criticized, supplemented and reinterpreted. Thompson[1] has shown that by means of computing correlations from the use of "imitation mental tests" coefficients may be obtained which group themselves in a hierarchical order similar to that found by Spearman; he has proposed a supplementary explanation which he terms "the sampling theory of ability." According to Thompson, correlations are affected by the operation of a number of group factors which are of wide influence and which, unlike the Spearman theory of specific group factors, are not mutually independent.

2. The Theory of Specific Factors.—Thorndike[2] applied Spearman's criterion to data collected from 15 tests of intel-

[1] Thompson, Godfrey H., General *vs.* group factors in mental activities, *Psychol. Rev.*, 1927, **27**, 173–190.

[2] Thorndike, E. L., On the organization of intellect, *Psychol. Rev.*, 1921, **28**, 141–151.

ligence representing the scores of 800 soldiers, and 7 mental and motor tests which were given to 900 soldiers. The results of the computations of intercorrelations from these sets of data indicated that, instead of there being one general factor, there were a number of specific factors which were not bound together by a common factor. As a result of his investigations, together with an analysis made from correlation data from time to time, Thorndike has proposed the theory of specific factors which is in closer agreement with the view of Thompson than that of Spearman.

3. **Evaluation of the Theories.**—In addition to the studies by Spearman, Thompson and Thorndike, other investigators have attempted to clarify the relationship of mental functions. The evidence has been derived from investigations dealing with the relation of phases of the same mental function, and from evidence dealing with the relation which different mental functions have to each other. A mental function such as memory may be studied with the purpose of determining the relationship between immediate memory and remote memory; or in the case of reasoning the relationship between reasoning in one situation and reasoning in another may be sought. With regard to the second line of evidence, correlations may be computed between memory, perception, reasoning and imagination. Objective results produced on these problems clearly indicate that, when different phases of the same function are correlated, the coefficients are usually positive but not high enough to indicate close relationship. In the case of memory, it may be shown that immediate memory does not correlate highly with remote memory, and that reasoning in one situation may not insure equal ability in reasoning in another situation.

A similar conclusion may be drawn by using a general mental test and correlating its different parts. The general mental test, designed as it is to measure many mental functions and abilities, offers an excellent example of the type of investigation which may be made to test the validity of the general factor theory. Studies indicate that there is a positive, though not high, correlation among the different parts of such tests. In

fact, the purpose for which general mental tests are devised would be defeated if there should be a close relationship between its different parts. In order for the composite score, resulting from performance on the entire test, to correlate significantly with an outside criterion of intelligence, such as teachers' estimates and school success, the various parts must show low correlation. If the different parts of the test correlated highly with each other, the conclusion would necessarily be that the test is not measuring different abilities, but one ability. Haught[1] has summarized as follows the results of an investigation which had for its purpose the determination of the interrelationships of some of the higher learning processes:

> This theory assumes that in carrying out any activity, such as a mental test, a number of factors are at play. Each activity involves a specific number of factors combined in a specific way. The specific factors combined will differ with different individuals and the same individual at different times. In this case there may be said to be an element common to all the activities. In other cases there will be no element or elements common to more than two or three of the mental functions. For instance, tests 1 and 2 may correlate because of element *a*, tests 1 and 3 because of element *b*, tests 2 and 3 because of element *c*, etc.

There is no doubt that mental functions are related, but whether this relation is affected by a common element *g* as Spearman suggests, or by some other unknown interrelationship, as suggested by Thorndike, is not yet determined. The theories are significant, in so far as they influence learning ability. Mental functions correlate with each other positively, though not significantly. Viewing the problem from a practical standpoint, success in the performance of mental functions depends to a considerable extent upon training and practice in those functions. Proficiency in reasoning in one type of situation does not indicate or insure equal efficiency in another reasoning situation; memory for one mental task may not be accompanied by the same ability in another. Proficiency in one mental function does not indicate or assure equal efficiency in another mental function.

[1] HAUGHT, B. F., The interrelation of some higher learning processes, *Psychol. Rev. Monog.*, 1921, 30, No. 139.

D. The Concept of General Intelligence

The discussion of the relation of mental functions leads to a consideration of the concept of general intelligence. Probably the best approach to the question of the meaning of intelligence is through an analysis of the instruments which are devised to measure it. The early mental tests were largely unsuccessful in measuring general intelligence because of their inclusion of a number of sensorimotor skills and because of lack of appropriate statistical devices. As a result of the study of early tests, it was soon discovered that, if a test of general intelligence were to be devised, materials which would measure the higher mental functions, such as reasoning, attention and memory, would have to be incorporated; at the present time most tests of general intelligence aim to include materials which measure all of the higher mental functions.

The general intelligence test attempts to "sink shafts" as it were into all the phases of the higher mental functions so that the total score on an intelligence test is the best index of an individual's general intellectual efficiency. The score which a pupil makes on an intelligence test, therefore, represents the performance of that individual in a diversity of situations and indicates the general level of intellectual capacity of the individual. More specifically, the intelligence test indicates the ability of an individual to adapt himself to a relatively complex situation. The relation between intelligence and success in the abstract subjects of school, as shown by tests, is usually much closer than the relation between intelligence and the so-called motor and manual subjects. For that reason, the intelligence test needs to be supplemented by tests of manual performance, skill and aptitude.

The relation between intelligence and achievement, as measured by school marks or by standardized educational tests and computed by numerical correlation, is usually about 0.50. As has been suggested by Terman, this relationship is high enough and low enough to be significant. Application, industry and study conditions are significant factors in achieve-

ment. The intelligence test is probably one of the most important instruments for predicting an individual's scholastic success as schools are now organized.

1. **Intelligence and Learning Ability.**—Some recent investigations indicate that there should be a differentiation between intelligence and learning ability. General intelligence, as measured by the intelligence test, comprising materials which evoke reactions in a diversity of circumstances, may be defined as the ability to respond to complex situations. Learning ability refers to the capacity to respond to a more specific and restricted situation, thus indicating that there is a focalization of attention on the particular task at hand. There is an integration and mechanization of responses with continued practice. Atkinson,[1] who is responsible for one of the most recent investigations of this question, makes the following distinction:

> In order to distinguish . . . between intelligence and learning ability, we may take the case of a subject continuing practice on an intelligence test. In so far as the subject's responses become restricted and specialized resulting in improvement (*i.e.* greater rapidity and a newer approach to his limit of ability) just so far do those responses become less intelligent and take on more of the nature of learning.

This view confirms the findings of Haught and others who have demonstrated the specificity of learning situations. Learning ability and intelligence are probably closely related and learning ability as measured by achievement is probably the best index of intelligence.

2. **Learning Ability and Types of Material.**—Following the discussion of the relation between intelligence and learning ability, the question arises whether learning ability is constant for all types of materials. Assuming that an individual has good learning capacity, will this capacity be manifested in all types of learning materials? One view is given by Pyle[2] who

[1] Atkinson, W. R., The relation of intelligence and of mechanical speeds to the various stages of learning, *J. Exper. Psychol.*, 1929, **12**, 89–112.

[2] Pyle, W. H., Is individual learning capacity constant for different types of material? *J. Educ. Psychol.*, 1919, **10**, 121–128.

studied the relationship of student performance in three types of "intellectual learning." Pyle's results show that the average correlation between one type of learning and another is approximately 0.50, on the basis of which he believes that learning capacity is constant for all types of materials.

Other investigators have found correlations between different types of materials to be much lower than those of Pyle, and the theory of constancy of learning has not been generally accepted. Whether one considers coefficients of correlation of 0.50 for different types of materials as representing constancy or variability depends upon one's point of view. Learning ability appears to vary with different types of materials and conditions. The correlations between learning in one type of material and another are usually positive, though far from perfect.

E. Summary

Heredity and environment are important determinants of success in learning. Any attempt to show the relatively great importance of one of these groups of factors as distinct from the other would be futile because the two are inseparably allied. Heredity determines possibilities and sets limits of achievement. Environment makes possible the development and expression of these innate capacities of the individual.

The function of education is to provide stimuli in the form of methods and incentives, which will aid the individual in developing his innate abilities. Although one should not discount possibilities for improvement by means of improved capacities or stimulated growth, the theory of specific techniques has the most data for its confirmation. The greatest opportunity for education consists in guiding and directing the learner in his reaction to the materials of the schoolroom. It is controversial whether or not education can improve innate capacity. However, it can improve methods of studying and learning, and therefore contribute greatly to individual and group efficiency.

Mental functions are positively related. This relationship is not, however, sufficiently close to warrant definite conclusions. From the practical standpoint, it does not necessarily

follow that success in one mental function will be accompanied by equal success in another. Practice and training are necessary for the efficient expression of mental functions.

Intelligence and learning ability are closely related. Intelligence is the ability to react to a diversity of situations; learning ability is the capacity to focalize on a specific situation. It involves the integration and mechanization of responses with continued practice. Learning ability is not constant for all types of materials and varies with the subject matter and conditions.

CHAPTER III

PERCEPTION, OBSERVATION AND REPORT

A. Perception

Perception consists in the recognition and apprehension of stimuli received through the medium of the sense organs; it is a process of supplementing and interpreting the sensory data, so that not discrete and isolated stimulus characters but whole objects and situations become the subject matter of the individual's behavior. Most of the early training of the child in the home and school consists in aiding him to apprehend stimuli within his immediate environment. It is essential, then, to an understanding of the learning process that the factors involved in perception be considered and the possibilities for its development determined. Original raw form and acquired meanings are two closely related elements in perception.[1]

During the child's early years he reacts to very vague wholes not distinct from their backgrounds or from somewhat similar wholes. To the young child just become familiar with a piano, any instrument which makes music is so labeled; to one acquainted with one automobile, all cars produce the same reaction. The vagueness of the child's perceptions is clearly noted when he is required to react to a standardized learning situation, such as the fitting of blocks into grooves as required by form-board tests. He haphazardly tries first one block and then another with little notion of the outline or distinctive form of the problem situation. With practice random effort is gradually diminished and the problem is solved with ease. With increasing age and experience he learns to make finer discriminations and to analyze more critically the elements

[1] Franz, S. I., and Kate Gordon, *Psychology*, New York, McGraw-Hill, 1933.

involved in a total situation. This transition from the ability to react to a vague pattern or form to the ability to comprehend more distinctly the precise pattern of details in a situation marks the development of perceptual ability.

Although forms based upon visual perception are most easily recognized, there may be forms developed on the basis of each avenue of sense impression as well as various combinations of them. There may be forms involving pressure, smoothness, taste, smell and sound. In these different modalities they are developed in varying degrees of clearness according to the experience and training of different individuals, for example, football players probably have highly developed perceptions in the kinesthetic field while musicians have keenly developed ones of an auditory nature. Individuals in general have perceptions in all of the sense avenues, though some will probably be more distinctly developed than others. Forms may also involve time and space relationships as well as other qualitative and quantitative characteristics.

The meanings of stimuli vary not only with different individuals, but with the same individual under differing conditions. It may be noted that in observing dots or figures ambiguously arranged, although the stimuli may remain constant, there is a variation in the perceptual attitude of the observer. In reacting to such situations the individual has sensations without being able to grasp their true meaning and thus shifts from one meaning to another. The meanings of stimuli may also vary with the contextual situation in which they are found. Words may have varying meanings when used in different sentences. Likewise, meanings vary with the different interests, training and experience of those who perceive. Natural phenomena have one meaning for a trained scientist and another for an ordinary observer. Factors causing variability in the interpretation of stimuli include the past experience and training of the observer, as well as the type of motor adjustment evoked by them.

Psychologists are not agreed as to the relation between perception and overt motor responses on the part of the

observer. Those who believe that perception involves or is based upon motor response point out that many of the child's perceptions are acquired through the manipulation of objects and that the child uses lip movements when first learning to read. Then there is also a tendency for children to define words in terms of use. Thus, overt motor responses as the carriers or determiners of meanings appear to be characteristic chiefly of young children. With increasing maturity, on the contrary, there is a tendency to inhibit movements so that if they occur at all they do not extend beyond the incipient stage. When confronted with baffling situations pressing for interpretation, the intelligent individual restrains action until he has discovered the nature of the situation. Thus many meanings may be expressed only by incipient movements. Likewise, many meanings are expressed only as emotional attitudes by facial expression as exhibited by joy or fright.

1. False Perceptions.—False perceptions include both illusions and hallucinations. An illusion is an incorrect interpretation of a stimulus. The stimulus remains constant but the individual perceives something that in reality is not objectively true. A hallucination, on the other hand, is a false interpretation, not of a present stimulus, but of an image which is taken to be an objective fact. Since hallucinations are abnormal experiences they do not concern us here.

An illusion may be due (1) to a confusion induced by *unusual conditions in the stimulus* or its environment, as, for example, the distortion of objects due to atmospheric conditions; or (2) to a *defect in the sense organ* of reception, such as the distortion of sound by defects of hearing; or (3) to a *predetermination* due to expectancy. More experimental work has been performed on the first type than on the others.

One of the common materials for such study is the Muller-Lyer illusion in which the lines between the brackets, although equal, appear unequal. By using cards so arranged that the length of one line may be varied while the other is held constant, the illusion can be measured and the effect of practice

determined. Both Judd[1] and Lewes[2] have studied the effect of practice on illusions. Judd's studies show that practice eliminates the illusion. Lewes studied the influence of momentary and prolonged periods of perception and found that practice has no influence on the illusion during momentary periods, but that it gradually disappears during prolonged periods. Judd's conclusion with regard to the value of experiments with this type of false perception is that

. . . organized perception does not consist in the rejection of factors in the field of vision, but rather in a proper synthesis of all of the factors into a single whole. Lower and higher stages of perception are thus to be described, not in terms of the amount or kind of content included in the percepts, but rather in terms of the mode of organizing such content as is present.

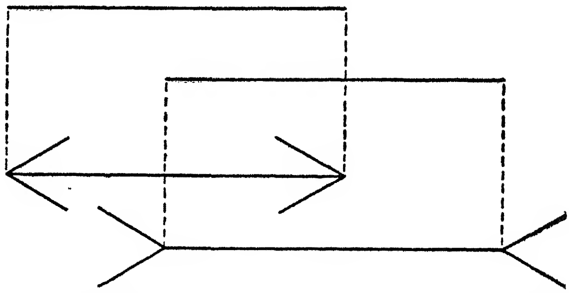

FIG. 1.—The Muller-Lyer illusion. The two upper lines are equal and look equal. The two lower lines are equal but look unequal.

Lewis confirms this point of view when he states that eye movements in the perception "become more systematic and the extremes of the lines fixated more accurately." Improvement in this type of illusion is largely a matter of improving the technique of perceiving.

A defect in a sense organ exerts a detrimental influence upon the perceiving process because it narrows the field by which

[1] JUDD, C. H., Practice and its effect on the perceptions of illusions, *Psychol. Rev.*, 1902, **9**, 27–39; also The Muller-Lyer illusion, *Psychol. Rev. Monog.*, 1905, **7**, No. 1.

[2] LEWIS, E. O., The effect of practice on the perception of the Muller-Lyer illusion. *Brit. J. Psychol.*, 1908, **2**, 294–306.

perception may be developed. Sensory defects may vary all the way from total disability of one or more sense organs, as in the case of Helen Keller, to slight defects in seeing and hearing. Since the greater part of perceptual knowledge is received through the medium of the eye and ear, a defect in one of these organs impairs the range and accuracy of perceptions. Defects of the eye cause words to be misread, and ear defects cause spoken words to be misinterpreted. Such defects cause illusions and misconstructions, and it is obvious enough that their detection and, if possible, their correction in the school child are exceedingly important for his learning.

The nature of preliminary knowledge and expectancy must be considered so that the teacher may aid the pupil in the development of adequate perceptions. It is often true that one perceives what one is expecting even though it may not exist in reality. It is in this connection that specific instructions appear so important if the pupil is to be expected to search for definite problems in preparing his lessons.

2. Individual Differences in Perception.—The complexity of the perceptual process varies directly with increased age and experience. Age provides maturation of physiological development and increasing years afford added opportunity for experience. Six-year-old children have little power of analysis, and interpretation is based upon the child's limited experience. Children from poor home environment tend to have much imagination. This condition seems to be due, not so much to self-active imagery as might be expected, but to poor environments which make creative imagination a compensatory asset. As a rule such children manifest little indecision, but give with confidence the most improbable interpretations. Suggestions are readily adopted and additions are frequently made according to the desire of the child. Children with good environmental background tend to make fewer imaginative additions to perceptions and are not so susceptible to suggestion. This difference is probably due in large part to better opportunities offered by good environment for a richer background of

Smith[1] tested the perceptual ability of twelve-year-old children in three schools which represented pupils from good and poor districts and a grammar school. The method consisted in showing pictures by means of lantern slides. His results show that children from the poor district tended to be passive in their responses to the pictures, while those from the good district and grammar school were more active. In practically all tests the children of the poor district had perceptual ability similar to that of six-year-old children, while those from the good district and grammar school showed ability more nearly approximating that of adults. Smith's findings are given in Table 7, which shows the comparative abilities of these children.

TABLE 7.—THE PERCEPTUAL ABILITY OF 12-YEAR-OLD CHILDREN (After Smith, 1914)

School	No. of subjects	Age	Av. no. correct facts in a picture	Av. no. mistakes in each picture	Av. no. correct reasons for things	Av. no. positions correctly described
1. Elementary (poor district)	2 girls 2 boys	6 6	10.9 7.1	8.0 9.6	0 0	2.1 1.5
2. Elementary (good district)...........	5 boys	6	10.5	6.15	0.15	3.35
3. Elementary (poor district)	3 girls 3 boys	12 12	14.5 12.58	3.58 7.0	0.4 0.25	3.8 4.75
4. Elementary (good district)	3 boys 3 boys	12 12	11.4 17.0	3.8 7.5	0.1 0.58	4.2 5.25
5. Grammar............	9 boys	12	19.4	3.15	0.4	7.6

Mentally defective children make little progress in perceptual ability and possess meager power to solve problems. Their

[1] SMITH, FRANK, An experimental investigation of perception, *Brit. J. Psychol.*, 1914, 6, 321–362.

memory is weak and their attention wanders. Contradiction and inconsistency, together with high suggestibility, are common characteristics of this group.

Wide individual differences are noted in the manner of perceiving. With some individuals a perceived experience assumes the reality of life and they react to it as if they were actual participants. Certain fairy tales and stories of adventure are so real to the imaginative child that he reconstructs them, substituting his own personality for that of his favorite character, and weaves in the details according to his own experience. The pupil who injects his own personality into subject matter acquires a vast fund of secondary experience which contributes toward the development of the higher intellectual processes and enriches his life. Teachers frequently observe that some members of every class perceive objects and situations as a whole, independent and unassociated with other objects and possible meanings; while others not only view objects and situations as independent, but see many meanings and associations and view them from many angles and possibilities. The former are often termed unimaginative because of their lack of ability to see relationships, while the latter are termed imaginative because they see many associations and implications in a single stimulus.

Environment and training are significant factors in perceptual power. Good home and school environment is closely associated with high intelligence, greater care in attacking problems and keener perceptual ability. Children who enter school at the age of six have a meager range of perception which is partially due to limited experience. This fact has been demonstrated by many studies, including the Berlin investigation of 1870 and the Lange, Hall and Meumann studies which have definitely shown that children should be given careful and extensive training in building perceptions during the pre-school and early-school periods. They have shown that the child's perceptions are indefinite, simple and confused, and that there is little that the school can take for granted with respect to the perceptions of any child who enters.

3. Improvement in Perception.—Ability in perceiving is basic to the development of learning and is susceptible to improvement through systematic training. The child cannot apply words, ideas or thoughts unless some meaning has first been attached. The process by which perceptual ability is developed is through systematic training in the development and application of meanings. The child's perceptual progress is directly influenced by the number and character of sensory defects which he possesses. Since progress in the development of perceptions is dependent upon adequate reception of stimuli, the school is responsible for detecting and correcting sensory defects.

Children of the pre-school and beginning school ages should be given training which will permit them to recognize the sense stimuli of their environment. Words and ideas should be associated with objects and experiences with which the child is familiar. The child's immediate environment should be sought and his experiences brought to light as a basis upon which to build future perceptions. Similarities are interesting and arouse a desire for increased information.

The program of the school should contain provisions for training in pupil activities. Although this training in the early years should be in the nature of motor responses, it is not confined to that. Even young children are capable of objectifying the ideas and abstractions read, through projects which are both motor and mental in nature. During the child's early years much use should be made of concrete and tangible materials, but as soon as language has become a medium of thought, the concrete materials must gradually be supplanted by abstract ideas. If the pupil thinks too long in terms of the concrete, his thinking will be retarded. He should be trained to make the transition from objects to symbols and from specifics to generalizations. Isolated and unassociated objects which form the basis for early training are not sufficient. Therefore, children should be taught to see objects in relation to other objects and ideas in relation to other ideas.

Perceptions should have the proper background so that the expectation on the part of the pupil will tend to prevent illusions and facilitate the acquisition of the perceptions considered. For each new topic or subject the teacher should prepare the pupil to make the transition from past experience to new material with the least amount of time and effort. The objectives of new subject matter should be pointed out so that the pupil may have a clear understanding of what is expected and a sufficient background for the recognition and orientation of new perceptions as they appear.

The method of developing perceptual ability has been variously discussed by investigators. Some have advocated that children who are reared in the country should be taken on trips to the city, while those brought up in the city should broaden their experiences by visits to the country. Nature study offers a valuable medium for the understanding of natural phenomena, while visits to local and state civic organizations furnish experience for those who study the social sciences. At any rate, it is recognized that in the effort to provide a short cut to experience the school has relied altogether too much upon abstractions which pupils are required merely to reproduce for advancement, but which are to them little more than meaningless terminology. The really important consideration is that words and symbols taught in the formal work of the school be objectified in the mind of the pupil by association with real and concrete experiences.

B. Observation

Observation is that process of directed attention which makes mental record of stimuli and their interpretations. This record remains as a memory and is reproduced through the medium of report. The more intense the observation, the clearer the perception, and therefore the more accurate the report. Careless or indifferent observation leaves a gap in the mental record which invalidates the report owing to insufficient details, or, through the self-active process, the mind fills in the gaps and illusions result. Observation is the process which

directs the attention to those specific elements considered worthy of mental record and future reproduction. It is the control feature of attention which extends beyond the mere recognition of forms and simple objects. Observation presupposes attention; but not all attention is observation. Rather attention localizes observation. Attitudes and incentives motivate attention while interest and effort intensify and prolong observation.

Observation is the chief means for the acquisition of information. Information may be obtained by two general methods: (1) observation of sensory stimuli from within—subjective observation or introspection, and (2) observation of sensory stimuli from without—objective observation. Introspection has been considered by many as unreliable because the effort to introspect tends to influence the reception of stimulations and bias interpretation. Objective observation, to be of value, must be both comprehensive and accurate.

1. Factors Influencing the Selection of Stimuli for Observation.—There are at least four factors which affect the selection of stimuli for observation. Two of these, preperception and terminology, may be considered primary factors, while assimilation and organization may be termed secondary factors. The latter are functions of the former.

a. Preperception and Terminology.—Preperception is the preliminary knowledge of an experience or a situation as determined by intellectual preparation for it. Preperception is a conditioning factor in attention and perception and thus in the entire process of observation. Lewes, who first used the term in 1879, suggested that previous experiences condition and prepare the individual for the reception of present stimuli. This conditioning process makes preperception an element in both perception and observation. James says: "The only things which we commonly see are those which we preperceive and the only things which we preperceive are those which have been labeled for us and the labels stamped into our minds. If we lost our stock of labels we should be intellectually lost in the midst of the world." In this point of view there are

two problems: (1) the effect of preliminary knowledge of an experience upon the accuracy of observation, and (2) the influence of terminology upon the process of observation.

Fox[1] performed a series of experiments to test James's theory and to seek a solution to these problems. In these experiments an effort was made to determine the effect of preperception of the items of an experience upon the ability to observe these items. His method consisted in showing to a group of individuals, by means of lantern slides, suits of armor. The subjects, most of whom were university graduates, were requested to observe the pictures as accurately as possible for a specified length of time and were later required to report everything they had observed. To provide preliminary knowledge a lecture was given to Group L. In this lecture attention was directed to the items of the pictures together with their technical terms. These technical terms, which had been only partially learned, at first proved confusing to the subjects, and inhibited the beneficial effect of the preparation for the experience. Even after repeating the experiment with other groups and in spite of the fact that care was taken to emphasize the items of the picture and their terminology, preliminary knowledge produced little improvement. Confusion, due to inadequate assimilation of terminology, persisted. It was evident that the individuals had not been given sufficient time in which to assimilate the information provided.

A final experiment was performed in which complete assimilation was the goal, and an entire week was allowed for its accomplishment. At the end of this time the final test was made. In addition to giving a detailed report of the items of the pictures, Group L told whether and how the lecture and technical terms influenced their observation, while Group N, that had had no preparation, told of the influence of the absence of these factors. The objective results of the combined scores for each subject for slides 1 and 2 for which no preparation was given and for slides 3 and 4 for which Group L had been prepared, are given in Table 8. From this table it may be seen

[1] Fox, Charles, A study in perception, *Brit. J. Psychol.*, 1924, 15, 1–16.

TABLE 8.—THE EFFECT OF PREPERCEPTION OF THE ITEMS UPON THE ABILITY TO OBSERVE THESE ITEMS
(After Fox, 1924)

Group L			Group N		
Subjects	Without preliminary knowledge, Slides 1 and 2, marks	With preliminary knowledge, Slides 3 and 4, marks	Subjects	Without preliminary knowledge, Slides 1 and 2, marks	Without preliminary knowledge, Slides 3 and 4, marks
a	94	153	p	61	85
b	54	114	q	60	94
c	53	107	r	53	75
d	51	107	s	57	55
e	42	102	t	42	45
f	39	118	u	41	81
g	21	82	v	29	67
Mean.......	50 6	111.9	..	49.0	71.7
M. D.......	14 2	14.1	..	10.0	13.8
C. of var....	28 0	12.6	..	20.4	19.0

that the variation for Group N remains practically constant while Group L shows a decrease in variability. Systematic training produced greater uniformity within the group. When the results of this experiment are interpreted in terms of the standard deviation, the relative difference produced by preperception may be obtained. This gain is found to be 57·7 per cent. Preperception increased the ability to observe more than 50 per cent over those who did not have the benefit of such preliminary preparation.

Preliminary knowledge of an anticipated experience produces in the observer a sense of expectancy and stimulates effort. He does not feel confused by the indefiniteness of the situation and proceeds to analyze it without waste of time and effort. There is purposefulness in his study. If he is further aided by adequate terminology, he is enabled to dismiss the various items with a name and later recall their nature. The principal function of preperception and terminology is to supply a plan for observation and make it systematic and definite. The

chief value of terminology is to facilitate description and analysis, to establish mental images by means of words and to aid in classification.

b. Assimilation and Organization.—It is evident from the study by Fox that preperception and terminology alone are not sufficient to produce improvement in observation. Too much terminology without assimilation led to confusion. Organization directs observation in an orderly manner, shows all perceptions in their proper sequence, permits of the formation of pertinent associations with known perceptions and facilitates assimilation. It is clear that the process of memorizing terminology and various forms of factual content without their organization and assimilation is not only a waste of time and effort, but is a hindrance to the learning process.

2. Improvement in Observation.—The ability to observe is possessed in some degree by all individuals. This ability manifests itself at a very early age and shows a continuous growth concomitant with physical and intellectual development. Motion and number[1] are believed to be as readily observed by children as by adults. Motion of any kind attracts the attention of the child long before the moving objects themselves become familiar. Since the child is still in the perceptual stage of development, he sees situations as a group of individual objects or perceptions rather than as a unified pattern. The adult sees the situation as a whole and the individual objects are only incidental to the completed pattern which experience has enabled him to form. For that reason the child observes numbers equally well and in many cases better than does the adult. In other situations the child's ability to observe increases with age. As the child develops more perceptions he constantly becomes better able to distinguish objects, to analyze situations and observe details. The details observed by the child are usually more isolated and less unified because his efforts consist in the enumeration of perceptions rather than the interpretation of situations.

[1] FREEMAN, FRANK N., *How Children Learn*, Boston, Houghton Mifflin, 1917.

With growth the child passes from the enumerative process to that of organization of perceptions already acquired in relation to other elements of a situation and interpretation on the basis of a unified group rather than as single perceptions. At the same time, each additional year of age, within limits, is accompanied by finer discrimination in sensory details. As the child grows older, he is better able to discriminate among finer shades of color, and develops keener senses of taste and tonal quality.

Book[1] studied 360 university students, 270 high-school pupils and 200 children of the sixth grade. He found that the ability to observe and report reliably upon the objects in their immediate environment may be improved by specific practice. Winch,[2] from a study of several groups of London children, found that practice in observation produces an increase of 40 per cent in the ability to observe. Practice makes for the formation and fixation of correct methods and habits of observing. Repetition of observation under the same circumstances serves to fixate the correct responses, eliminate those which are erroneous and suggest items not previously observed.

Guidance is an important factor in the development of the technique of observation. The experiment by Fox shows that preliminary knowledge improves the process of observation. Incentives to observe should be provided and inquiring attitudes should be developed. Interest may be aroused by pointing out peculiarities, associations and relationships with previous experiences. Observed materials should be properly organized to show major and subsidiary elements. Training in the methods of keeping records of observations and the development of habits of attending to even the minutest detail are the chief means by which observation may be improved.

C. Report

No matter how accurate the perception or how critical the observation, the ultimate test is the observer's ability to report

[1] Book, W. F., Studies in observational learning, *Indiana Univ. Bull.*, 1918.

[2] Winch, W. H., Can observation be trained in school children? *J. Educ. Res.*, 1927, **15**, 229–238, 314–326.

with accuracy and completeness that which has been observed. The psychology of report has received much study since Binet[1] called attention to the practical importance of developing a science of testimony which received its earliest impetus among the German scholars in law. Stern has been one of its chief advocates and has been responsible for much literature in the field. In the United States, Whipple has been one of the leaders both in interpreting the work of German scholars and in showing its educational implications. His work and the more recent investigations of McGeoch have been adopted as a guide for the discussion which follows.

Whipple[2] was interested in three problems: (1) the determination of accuracy and range of report, (2) analysis of the factors influencing report and (3) suggestions of ways by which improvement in report may be produced. In addition to these general problems, he studied such factors as age and sex differences and the influence of intelligence upon report.

The studies dealing with report have usually employed the analytical and experimental methods of study. The analytical method consists in a critical analysis of reports of events as recorded in legal statutes, newspapers, conflicting opinions with regard to battles and the differences found in interpretations of movements and tendencies in historical accounts. In the experimental method observations are controlled and the results are objectively measured and statistically described. Of the two methods of investigation, the experimental procedure is more reliable and in recent years has been almost exclusively employed.

When the experimental method is followed, several types of tests are used. The picture test has been frequently employed because it is simple, adaptable and may be identically repeated for the purpose of comparison. The event test has been used by some investigators when it was desired to study report upon human activities under realistic conditions. Recent use of the

[1] Binet, A., *La Suggestibilité*, Paris, 1900.

[2] Whipple, Guy M., The observer as reporter: a survey of the psychology of testimony, *Psychol. Bull.*, 1909, **6**, 153–169.

event test is illustrated by the talking pictures taken of cross-examinations of criminals. Still another, the rumor test, has been used as a basis of comparing the relative value of reports based upon hearsay and eye-witness evidence. Other tests have been used but have not gained general recognition.

Reports are usually made in narrative or interrogatory form. The narrative report consists in giving voluntarily an account of that which has been observed or experienced. With the interrogatory form, the individual answers a series of questions covering the events or objects observed. The interrogatory form may be complete or incomplete. When the incomplete form is used, the observer is asked questions about his experience which were not covered in his narration. The complete interrogatory form consists of detailed and exhaustive questions which cover every feature of the individual's experience. Classroom illustrations can be found in the voluntary recitation or the essay type of examination which represents the narrative form and the new type of examination, and some forms of the old type which represent the interrogatory form.

Another problem in studying report is the determination of reliable methods of scoring. Two problems occur in this connection: (1) the determination of the best method of showing quantitatively the relation between experience and report, and (2) the establishment of adequate indexes which characterize the reporter's efficiency. In scoring a report there are several factors which must be taken into account. These factors include the range of items named or the questions answered, the accuracy and the degree of assurance with which the reporter makes his statements. The first two factors may be objectively measured while the third affords much opportunity for subjective estimation.

The studies of report have been conspicuous in showing that reports of both children and adults are seldom free from error. This condition exists, not only among laymen, but among especially trained observers. This fact in itself has been largely responsible for widespread interest in the problem and the increased emphasis upon training for observation in the schools.

The problem is significant only in so far as ability to report may be improved.

1. **Factors Influencing Report.**—Factors influencing report include both those which are contained in the report itself and those which are furnished by the age, intelligence, sex and maturity of the reporter.

a. Attestation.—Attestation does not guarantee accuracy, although the number of errors in unsworn report is about twice as high as in sworn testimony. Errors are found frequently as high as 10 to 14 per cent in sworn reports while they may be as high as 20 or more per cent in unsworn reports.

b. Time Intervals.—When other conditions are constant, accuracy and range of report tend to decrease with the increase of the time interval between observation and report. This is especially true of meaningless materials, while the loss of meaningful materials due to the time element is considerably less. In some cases the report seems to improve with a short time interval, and then to grow poorer with an increase of time. Borst[1] computed a fairly constant decrease in accuracy due to lapse of time, and found during a period of six days that the decrease in accuracy was practically 0.27 per cent per day. Some of her findings are shown in Table 9. Stern, working on a similar plan, found a decrease of 0.33 per cent per day. It is probable that the rate of loss is very complex, owing to other conditioning factors, and that the variation is due largely to the personal equation of the reporter and the type of material considered, rather than to the freshness of memory.

TABLE 9.—EFFECT OF TIME-INTERVAL ON RANGE AND ACCURACY
(After Borst, 1909)

Form of report	Narrative		Deposition	
Intervals in days	3	9	3	9
Range, per cent	40.6	39.6	67.2	65.5
Accuracy, per cent	89.5	87.9	82.6	83.4

[1] WHIPPLE, *op. cit.*

c. Content or Features.—The selective process operates in both observation and report. Certain features of the experience are accepted while others are rejected. Observers react with greater accuracy toward persons and their acts, objects and spatial relations, while they react with greater inaccuracy toward secondary features such as quantities and colors. Cady[1] notes that

> . . . the material which is most often repeated correctly is that which has been best presented, that which applies most directly to ourselves, that which falls into a general scheme of organization, and that which can be reported upon with generalizations. The matter which is reported with the greatest number of errors is that which deals with very particular information, and that which deals with facts which we habitually treat in some standardized manner. The material which causes the greatest amount of confusion is that which so closely resembles other material presented that it does not stand out with any individuality of its own.

d. Form of Report.—The interrogatory form of report increases the range and decreases the accuracy of report. Cady maintains that in narrative reports both general and specific facts are likely to be accurately reported, while the interrogatory reports are influenced by the number of items in the list and the form of questions. She finds that range is greater in the narrative than in the interrogatory form of report. However, she shows that as high as 74 per cent of the details are omitted in the narrative. Accuracy of report is increased when a combination of the narrative and interrogative forms is used, especially when the narrative precedes the interrogatory type.

e. Types of Questions.—Leading or suggestive questions tend to decrease the accuracy of the report noticeably for children and to a degree for adults. Questions which suggest the wrong and do not imply correct answers produce the greatest degree of inaccuracy.

f. Hearsay and Eye-witness Evidence.—When an observer tells his experience to another who in turn transmits the story to still others, both range and accuracy of report are reduced.

[1] Cady, Helen M., On the psychology of testimony, *Amer. J. Psychol.*, 1924,

Many individuals, when listening to a report, interpret inferences as facts rather than accept only the facts as stated. This principle illustrates how many rumors with little foundation originate and expand into tremendous proportions before they can be checked. When an individual sees or experiences the object or event, both accuracy and range of report are more reliable.

g. Repeating a Report.—Whipple[1] says:

> When a given reporter is called upon to make his report several times, the effect of this repetition is complex for it (1) tends in part to establish in the mind the items reported, whether they be true or false, and (2) it tends also to induce some departure in the later reports because these are based more upon the memory of the verbal statement than upon the original experience itself.

2. Individual Differences in Reporting.—Reports of children are in every way inferior to those of adults. This inferiority is partly due to a lack of experience which makes the child open to suggestion. The child's range of report is narrow and his inaccuracy is large; his assurance is high and consequently his warranted assurance and reliability of assurance are low. Range increases more rapidly with increase in age than does accuracy. Range may increase as much as 50 per cent between the ages of seven and eighteen while accuracy may not increase more than 20 per cent. This increase is not continuous and is not the same for all tests used. The event test indicates the greatest tendency toward increase; the picture test is next, and the object card third. Improvement in the ability to report grows from mere enumeration of items by very young children through a more careful report of description about the eighth year to an evaluation of spatial, temporal and causal relations in the years prior to adolescence. From adolescence on increase is more continuous and is accompanied by the ability to make qualitative analysis of experiences.

Intelligence is significantly related to report ability for both forms of report, although the narrative is more closely asso-

[1] WHIPPLE, *op. cit.*

ciated with intelligence in cases of extremes of brightness and dullness. For individuals between these extremes there appears to be no definite relationship. Mentally defective individuals are less accurate. Their reports are fragmentary and disconnected and they are very susceptible to suggestion. Persons of culture have greater range and accuracy than do uncultured persons, and they have less tendency to make sworn testimony in answer to suggestive questions. Here again the relation between intelligence and the ability to report is influenced by the method of measuring report and the type of material upon which it is made.

Experimental evidence is conflicting with regard to the influence of sex upon the ability to report. Breukink[1] reverses the findings of Stern[2] while Borst[3] disagrees with both. McGeoch[4] clarifies the problem when he shows that sex differences in the ability to report are partly influenced by the material upon which report is made. With some types of material men are superior, while with other kinds of material the women excel, and with still other kinds there is essentially no difference between the sexes. Cady's conclusion[5] that there is practically no difference between men and women in the accuracy and range of report is probably the most nearly correct.

3. Improvement in Report.—Training in report is the most effective means for its improvement. The several factors involved in report vary in their susceptibility to training but all of them improve with practice. This training may be effected for young children by an appeal through interest for common objects and experiences of their immediate environment. For the more mature and intelligent pupils systematic training of an intellectual character involving causal relations may be pro-

[1] WHIPPLE, GUY M., The psychology of testimony, *Psychol. Bull.*, 1910, **7**, 365–366.

[2] *Ibid.*

[3] *Ibid.*

[4] MCGEOCH, J. A., The influences of sex and age upon the ability to report, *Amer. J. Psychol.*, 1928, **40**, 458–466.

[5] CADY, *op. cit.*

vided. With the onset of adolescence and beyond, training may be increasingly more intellectual and include logical method and qualitative analysis. Lipmann[1] has suggested the following means for improving the report ability of pupils:

. . . The training in giving reports must imitate and accelerate the process that otherwise mere increasing years and the accompanying accumulation of daily experiences brings about—the transformation of the child's distribution of attention to one corresponding to that of the adult. Several methods for accomplishing this training are conceivable. For one thing one might use the report experience itself as a means of training. From the questions that are asked in this the child gradually learns what details he must notice. Such a training in reporting might easily be added as memory instruction to the usual instruction in observation. The only difference would lie in the fact that the objects would be described by the child not during perception, but after they had been shown to him and then taken away. Moreover, the instruction in observation itself may be used as a training in reporting in that during the child's very perception of the object his attention may be called to the essential details and concentrated on just those details. . . . A second very essential factor in a child's report can be influenced by memory instruction. By calling the child's attention to his misstatements one teaches him to take a critical attitude toward his own report. In this way he learns more quickly than he would learn through ordinary experience . . . that gaps in his memory may not be filled in at his own sweet will: that all material for the filling in that is furnished by fancy, custom or suggestion must first be tested as to its agreement with the actual experience reported; finally that if all material that comes to mind for filling in the gaps fails to stand the test of a thorough criticism the answer "I don't know" is to be preferred to every doubtful answer.

D. Summary

Perception, observation and report are interrelated and basic elements which underlie the learning process. Perception consists in the recognition and apprehension of stimuli received through the medium of the sense organs. The efficiency of observation is measured by the range and accuracy of report. An accurate report is dependent upon assimilation and correct interpretation of the materials observed.

[1] Lipmann, Otto, Pedagogical psychology of report, *J. Educ. Psychol.*, 1911, 2, 253–261.

The ability to observe may be improved by specific practice. Improvement of a general character may be obtained by the acquisition of appropriate techniques of observing and recording materials observed.

Practice in reporting improves the ability to report. The range and accuracy of report are influenced by those factors which are inherent in the report itself, and by those which are embodied in the personality of the reporter. The first include form of report, types of questions, content and features; the second comprise such factors as age, sex and intelligence of the reporter. For children of beginning school age, whose reports are largely enumerations of the objects within their own environment, improvement may be developed by an appeal through interest which they have for concrete objects of their experience. For older and more mature pupils who are capable of perceiving relationships, training of an analytical nature may be provided. With adolescent groups training may be increasingly more complex and involve critical analysis and evaluation.

CHAPTER IV

NEUROLOGICAL AND PSYCHOLOGICAL BASES OF LEARNING

Learning may be generally described as a change which occurs as a result of response to stimuli. In experience there is an awareness of certain sensations produced by stimuli which elicit some sort of response. Change, when considered in terms of learning, is essentially a modification of behavior. This modification must consist in improvement if it is to constitute learning, for otherwise it is deterioration or forgetting. Improvement implies adjustment to varying conditions. Consequently, learning may be defined as progressive adjustment to continuously changing conditions of life. When applied to the formal learning of the school, such a definition should be interpreted as progressive adjustment to the increasing complexity of the various school subjects.

The learning process may best be understood through systematic study of behavior. Although behavior is the manner in which the organism conducts itself in the presence of stimuli, not all reactions of the organism to stimulation constitute learning. Behavior of this type is of two not clearly differentiated classes: simple reflex and instinctive activity. These reactions, which are not the result of the learning process, lie at the basis of learning.

About the precise nature of reflex and instinctive activity there is as yet much debate. Certain muscular movements are the result of sensory stimulation and are termed simple reflex activities. They have no particular goal and are ends in themselves. More complex types of behavior which find expression without the influence of experience are conventionally called instinctive. The chief difference drawn between reflex and instinctive activity is their degree of complexity. It

is also often maintained that instinctive activity is a combination of reflexes which function toward some definite end. Even when the organism is partially aware of its activity, this awareness is not essential to the expression of the instinct. Both of these aspects of behavior are susceptible to modification, and they are important as elements basic to learning.

Reactions to stimulation constitute learning only when the individual has had experiences which may operate in modifying his reactions. There is a tendency toward consistency and persistency of performance under the same or similar stimulations. This acquired uniformity of performance is termed habit. Habit thus is the result of learning and may be defined as the preferred response to a given situation. Learning involves the acquisition and modification of these behavior patterns. The ability to learn is dependent upon the plasticity of the nervous system in reacting to stimulation. The value of education depends upon the ability of the organism to modify its reactions. It is, therefore, important to know whether there is a limit to the ability to acquire new habits and to modify or eliminate those already formed.

A. Neurological Bases of Learning

The science of psychology deals primarily with behavior and the experiences of the behaving person, but, in order that such activity may be interpreted, the mechanisms of behavior must also be briefly considered. Psychology is concerned chiefly with the functional aspects of the behavior mechanism; but, since function depends upon structure, it must also consider the structural basis of function. Psychology is indebted to both neurology and physiology.

The neurological aspects of behavior are best revealed in the stimulus-response system. How is the organism stimulated? What takes place in the nervous system following stimulation and how is response produced? Whatever disagreement there may be as to the nature of the neural process, it is certain that, before learning can take place, there must be formed a complete circuit within the nervous system between the point of stimula-

tion and the response mechanism. This circuit is termed the nerve path, whether it be simple or complex, and the current which travels over it is the nerve impulse, which is a form of physiological energy. This whole process involves the problem of nerve conduction of which very little is known. Psychology is incidentally interested in the structure and function of this circuit, and much psychological theorizing has been based upon certain more or less hypothetical neurological concepts. Some of these will be discussed.

1. **Character of the Nervous System.** *a. The Receptors.* Anatomically the reception of stimuli is made possible by sense organs—sensitive cells located within the body, called receptors. For each sense there is a receptor specialized in structure to enable the organism to receive particular stimuli. The stimulus serves its purpose when it excites the proper receptor. In time it ceases to function or the organism builds up resistance to its stimulating effect.[1]

Perrin and Klein[2] have classified the receptors as follows:

A. The somatic receptors:
- 1. Exteroceptors.
  - *a.* Distance receptors.
    - (1) Organ of vision—the eye.
    - (2) Organ of audition—the outer ear, middle ear, vestibule and cochlea of inner ear.
    - (3) Organ of smell (also an interoceptor)—olfactory epithelium of nose.
  - *b.* Contact receptors—the cutaneous sense organs.
    - (1) Organs of touch and pressure.
    - (2) Organs of heat.
    - (3) Organs of cold.
    - (4) Organs of pain (in addition to interoceptors for visceral pain).
- 2. Proprioceptors.
  - *a.* Organs of position and equilibrium—semicircular canals, saccule and utricle of the internal ear.

[1] Cohen, L. H., The relationship between refractory phase and negative adaptation in reflex response, *J. Comp. Psychol.*, 1926, 9, 1–16.

Telford, C. W., The refractory phase of voluntary and associative responses, *J. Exper. Psychol.*, 1931, 14, 1–36.

[2] Perrin, F. A. C., and D. B. Klein, *Psychology*, New York, Holt, 1926.

- *b.* Organs of kinesthetic functions.
  - (1) Organs in muscles.
  - (2) Organs in tendons.
  - (3) Organs in joints, or on articular surfaces.

B. The visceral receptors:

- 1. Interoceptors.
  - *a.* Receptors of the digestive system.
    - (1) Organs of smell (listed above).
    - (2) Organs of taste—taste buds on tongue and pharynx.
    - (3) Organs or sensory cells of hunger—in stomach.
    - (4) Organs or sensory cells of thirst—in mucous membrane of pharynx.
    - (5) Organs or sensory cells of nausea—in stomach.
  - *b.* Receptors of circulatory system.
  - *c.* Receptors of respiratory system.
  - *d.* Receptors of reproductive system.

These receptors are sensitized to stimuli of specific character. To be effective a stimulus must excite its own receptor. This does not mean that the organism reacts to separate stimuli as such. Both animals and human beings react to situations rather than to individual stimuli, but the situation must come to the organism through the medium of receptors. Reaction is to a combination of stimuli, or a pattern.

The theory generally accepted is that a stimulus generates or releases a nerve impulse in the receptor. This impulse travels, probably by some electrical or chemical process, along the nerve that leads from the receptor to the central nervous system. The path thus followed is the afferent path and its function is to transmit impulses to the central nervous system.

b. The Central Nervous System.—The brain and the spinal cord constitute the principal centers of connections in the nervous system between the afferent (incoming) and efferent (outgoing) nerve impulses. The cerebrospinal nervous system is the center of connections for impulses which have their origin in the exteroceptors and proprioceptors. Its psychological importance lies in the fact that here connections are formed in the process of learning. Since the autonomic system is only

indirectly involved in learning, it will be omitted from the discussion which follows.

The neuron from the structural standpoint is the most important unit of the central nervous system, since by its association with other neurons it furnishes a pathway for the transmission of nerve impulses. Much controversy with regard to the neurological aspect of learning deals with the method of the formation of connections and the selection and alteration of paths through the central nervous system.

The neuron is different from other cells of the body in that it has branching processes, the dendrites and the axon. Nerve impulses pass through the neuron in only one direction—in through the dendrites and out through the axon. Since there are numerous dendrites, the neuron is capable of receiving impulses from many afferent nerves. There is only one axon, but the axon frequently has collateral branches proceeding from it at right angles and forming connections with the dendrites of other neurons. At the terminus of each axon and branch there is a plate-like ending which is termed the *terminal aborization.* Most explanations of learning have been based upon the theory that there is resistance to nerve impulses at the point of contact between the ending of the axon or one of its branches and the dendrite of another neuron. This point of contact is called the *synapse*, and the term *synaptic resistance* has been employed to explain the process of habit formation, the theory being that, once a nerve impulse has succeeded in breaking down resistance and is followed by frequent similar impulses over the same path, a habit is neurologically formed. Experiments by Lashley and Franz[1] tend to question the validity of this theory as an explanation of habit formation. Some habits atrophy as a result of the destruction of certain parts of the cortex while others are not so affected. In any event, it seems essential to regard the synapse as important in

[1] LASHLEY, K. S., Studies of cerebral function in learning, *Psychobiology*, 1920, 2, 55–127; *Psychol. Rev.*, 1924, 31, 369–375.

FRANZ, S. I., Variation in the distribution of the motor centers, *Psychol. Rev. Monog.*, 1915, 19, 80–162.

the selection of neurons toward which to direct the impulse coming from the cell body. The exact nature of this process is still unknown.

The function of the central nervous system is to organize afferent impulses and to direct them over efferent paths to the reaction system. This process is known as association, which involves the organization of related impulses into a compound impulse for transmission to motor centers. This phase of the associative process is significant for learning because a multitude of stimuli constantly excite the organism and send afferent impulses to the brain and spinal cord. Were it not for some process of correlation the organism would be entirely confused by a battery of impulses. However, the organism does not react to stimuli as such, but to situations, and this process may be partially explained by the correlation and modification of impulses. The combination of sensory elements which constitutes a situation is received in the central nervous system as diversified impulses, each following an afferent path from its immediate receptor. These impulses must be arranged in a definite pattern before they can have more than desultory effect upon the motor centers. This pattern is assumed to take place in the correlation centers, one of which is the thalamus.

Just as a combination of stimuli excites the receptors of the organism, sending impulses to the correlation centers, these correlation centers are constantly transmitting a variety of organized impulses to motor centers. There is need for regulating and combining these impulses in order to produce harmonious action, for otherwise the organism would have no control over its responses. This coordination occurs in the motor areas of the central nervous system. From these centers the impulses, now efferent, are transmitted to the effectors or the organs of response. This act of coordination determines the nature of the ultimate response; if it were absent the organism would be confused by a hopeless jumble of reflexes. An illustration of this condition may be found in the case of intoxication which deadens the centers of coordination.

The method by which this coordination is effected is not definitely known, but the theory generally proposed is that of

facilitation and inhibition. These are principles which are based upon observation of behavior, rather than upon any knowledge of the neural activity involved. It may be observed that certain stimuli have a facilitating effect upon response, while others inhibit or weaken it. If reaction is to be a response to a situation rather than to stimuli as such, there must be a facilitating process that strengthens the effectiveness of some stimuli while inhibiting the effectiveness of others. This process is experimentally observed as selection and elimination and will be discussed under theories of learning. The interest of education in the problem of association and its functions of facilitation and inhibition is not so much in how these are neurologically effected, but in how they may be trained so that the organism may progressively adapt itself to continuously changing conditions of life. A knowledge of the mechanism of association should contribute toward an understanding and appreciation of the behavior of the organism.

c. The Effectors.—The organs involved in the mechanism of response, termed *effectors*, constitute the observable aspects of the neural process known as behavior. In the observation of their activity as the organism seeks to adjust itself to its environment, the degree of learning that has taken place may be measured. As their function is important to education, it may be understood better if something is known of their structure.

The coordinated impulses leave the motor centers over the efferent paths which lead to the proper effectors for producing the correct reaction. The neurological process by which the organism makes this selection is unknown. It is known, however, that the proper selection may be made, and that the organism may be aided in the process, by training. Upon reaching the terminus of the efferent nerve or its branches, the impulse is discharged into the effector and activity results.

The effectors may be grouped under two principal classes, corresponding to the respective receptor divisions: the somatic and the visceral. The somatic effectors are the skeletal muscles or the muscle-bone units whose function is to aid the organism in making adjustment to environment. The visceral effectors

include the smooth muscles and the glands. The smooth muscles are involuntary and are found in the walls of the alimentary canal, blood vessels, bladder, iris and the hair follicles.

The glands are organs of secretion that function partly in response to stimuli. They consist of the duct glands, the kidneys, the liver, the salivary glands, the sweat glands and certain glands in the walls of the stomach and intestines; and the ductless glands or endocrines including the pineal body, the pituitary, the thyroid, the thymus gland, the adrenal gland and the gonads. The duct glands function in connection with vital physiological processes and are only indirectly related to learning. The ductless glands are believed to influence drives and emotions because of their functions in connection with such vital processes as growth, mental activity, nervousness, blood pressure and sex characteristics.

All observable effect of stimulation which the organism receives from its environment is manifested through the functioning of these effectors and they are the only means at the disposal of the organism for making adjustment to the changing conditions of its environment. It is this resultant activity due to stimulation which is termed behavior and by which efficiency is judged in coping with environment. The method employed by the organism in learning to make such adaptation is a matter for conjecture and scientific study.

2. Some Neural Explanations.—Thus far in the discussion of the neural processes involved in learning a point-to-point conduction path theory has been implied. It is pertinent to question the validity of a process so simple, although most of the current explanation principles have been based upon this concept. The point of view has been challenged by Lashley and others; yet no principle has been set forth which is supported by sufficient experimentation to warrant a different approach. The difficulty lies in the explanation of the functioning of the central nervous system about which several theories have been formulated. The function of the receptors with their afferent paths of conduction, as well as the function of the

efferent paths and the effectors, are fairly well established, although the exact nature of the nerve impulse, whether electrical or chemical, or of another nature, is a matter for conjecture. But it is not clearly understood how the connection is made between afferent and efferent systems. The majority of theories assume specific connections. Lashley[1] and others suggest that the dynamic forces in nervous activity

> . . . may be electrical or electro-chemical, diffuse or conducted through the nervous network, continuous or intermittent. They may act as an accessory to the anatomically restricted reflex functions, modifying the conductivity of nerve impulses; or they may constitute the sole basis of nervous integration, giving the illusion of definiteness of structural connection where the conditions of their activity are simple.

The process by which substitute stimuli produce the same reactions as original stimuli has elicited the conditioned reflex as an explanation for association. Since Pavlov first formulated the conditioned reflex hypothesis psychologists have accepted it as a general working basis for theories of neural function.

The earlier explanatory principles for learning were based upon the association of ideas. It was held that when one idea was closely related to another it tended to produce the same response as its correlate. Certain laws such as contiguity, frequency, intensity, primacy, recency, effect and mental set were believed to operate in producing this similarity of response. The presence and function of these factors were recognized, but a more objective basis was desired. It was to be expected that the conditioned reflex hypothesis with its simplicity, definiteness and objectivity would become popular. The fact that an auditory stimulus may be substituted for a tactual stimulus in eliciting the salivary gland reflex seems a logical basis for explaining association, provided the point-to-point conduction path holds true. Lang and Olmstead[2] discovered that the original afferent path must remain intact if the conditioned

[1] LASHLEY, K. S., *Brain Mechanisms and Intelligence*, Univ. of Chicago Press, 1929.

[2] LANG, J. M., and J. M. D. OLMSTEAD, Conditioned reflexes and pathways in the spinal cord, *Amer. J. Psychol.*, 1923, 65, 603–611.

afferent path is to function. Their experiment raises some question as to the validity of the simple reflex theory in conditioning. Lashley, Franz[1] and others have also shown that specific paths appear not to be essential and that a learned reaction may be performed by the functioning of an entirely new set of receptors and afferent paths nonactive in the training period.

a. The Theory of Kappers.—Kappers[2] has formulated a theory which he calls *neurobiotaxis* to account for the structural

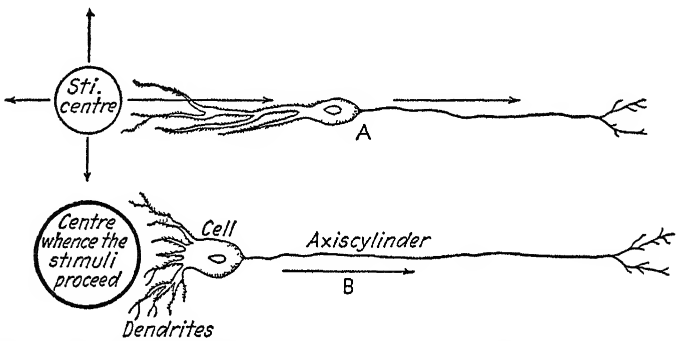

FIG. 2.—Showing that, while the axis-cylinder runs with the direction of the nervous current, the dendritic outgrowth and the final shifting of the cell body occur against the nervous current. *A*, giant dendrites grown out towards the center of stimulation. *B*, the cell body (perikaryon) has shifted toward the center of stimulation; the axis-cylinder is consequently elongated. (*After Kappers, op. cit., p.* 266.)

development of nerve fibers and their relationships and connections. According to this theory the nerve impulses that reach the central nervous system, particularly by the way in which they are related, determine or mold the structure and arrangement of the nervous system. Kappers claims that when a nerve impulse passes along an axon fiber the fiber radiates electrical energy (potential). Neuroblasts, embryo nerve cells that lie near such an axon, are stimulated to growth by this potential, provided they are related in function (this functional difference in neurons is assumed, but is probably

[1] FRANZ, *op. cit.*

[2] KAPPERS, C. V., Further contributions on neurobiotaxis, *J. Comp. Neur.*, 1917, 27, 261–298.

correct) to the active axon. Other neuroblasts are unaffected. The stimulated neuroblasts send out dendrite and axon fibers. The dendrites grow toward the source of stimulation, the active axon, while the axon fibers grow away from it. The cell

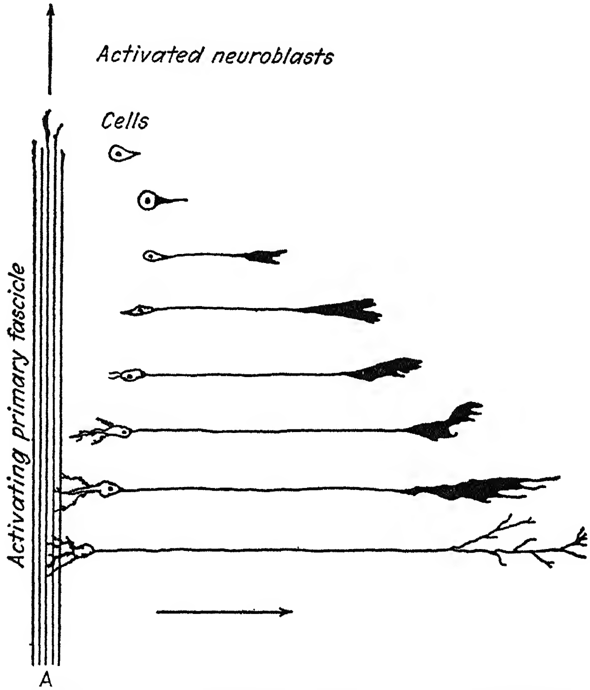

FIG. 3.—The activation of adjacent neuroblasts by an amyelinated (growing) fascicle. The vertical arrow indicates the direction of growth of the activating bundle and the direction of its nerve current, which starts at *A*. The horizontal arrow indicates the course of the irradiating influence (current) perpendicularly to the activating bundle. Notice that the proximal cells are sooner activated (and have moved further) than the more distant ones. After Bok. (*After Kappers, op. cit., p.* 268.)

body of the growing neuron gradually moves closer to the source of stimulation (Fig. 2) and the axon fiber becomes elongated, continuing its growth until it comes in contact with the dendrites of another neuron already developed, the function of which is related to that of the growing neuron. Thus the nerve impulse from the original axon is passed on through this new neuron and out by way of its axon to the next related neuron

In this manner nerve impulses are spread and the association of two or more related stimuli effected. This stimulated growth of the axon (Fig. 3) has been termed by Bok[1] *stimulogeneous fibrillation.*

Such a theory commends itself at first because of its seemingly logical and factual basis. But, as Lashley[2] observes, it involves a process of growth that is too slow to account for associations, which must be quickly made in nearly all the practical phases of the learning process. It will fail as an acceptable theory if it can be proved that the point-to-point theory of nerve conduction does not hold. Furthermore, it gives no clue as to the manner in which the nerve impulse is transmitted from the axon of one neuron to the dendrites of another at the synapse.

b. The Theory of Johnson.—Johnson[3] has evolved an hypothesis based upon knowledge of physical and chemical laws to account for such transmission by what he terms *suctional drainage.*

Johnson assumes the nerve impulse "is essentially an example of *directed* and *intermittent electrical conduction effected* by the *virtual* transfer of *positive ions* from receptor to effector through intervening conduction cells called neurons."[4] By this he means that if a receptor is excited, typical positive ions, such as those of hydrogen, move in the direction of the effector. A single positive ion need not traverse the entire length of the circuit, but moves only to the next orientated molecule in the line of conduction where it pairs with a dissimilar ion whose positive mate moves on. Transmission of positive ions is thus virtual, rather than actual, with respect to the entire circuit.

The heart of Johnson's theory is in his attempt to explain how the nerve impulse passes from one neuron to another. He assumes a surface film formed on the surface membrane of the

[1] *Ibid.*, 267.

[2] LASHLEY, K. S., (In) *Foundations of Experimental Psychology*, Clark Univ. Press, 1929.

[3] JOHNSON, H. M., A simpler principle of explanation of imagination and ideational behavior, and of learning, *J. Comp. Psychol.*, 1927, 7, 187–235.

[4] *Ibid.*

nerve cell by the clinging to it of ionized molecules, which are oriented with respect to the membrane, that is, the charge of the film molecules must be opposite to that of those within the membrane. Metabolic changes within the cell are, however, constantly sending ions through the membrane, causing continuous oscillation in the fiber. This oscillation or shifting back and forth affects the ease of conduction through the surface membrane. When the rate of oscillation of two cells is the same, conduction from one to the other may occur. The frequency of oscillation of one cell may be tuned to the frequency of another by "forcing"—a mechanical principle involving the ability of one vibrating object to cause another to vibrate at its rate. In this manner a nerve impulse may force its way across a multiple synapse and the frequency of conduction cells may be modified or "educated" in the learning process. The ability of an adjacent cell to force the frequency of another cell depends upon several factors, such as intensity of the stimulus, duration of the stimulus, reinforcement, whether by increased attentional strain or by emotional tone, and repetition of the external stimulus or of its substitutes.

Johnson, in the theory of suctional drainage, "negatively induced excitation," attempts to explain the phenomenon of conditioned response, which is produced by a substitute stimulus as distinguished from direct stimulation of the ordinary receptors with subsequent response. He uses this theory to explain imagination and other intellectual responses which depend upon substitute stimuli acting upon a substitutive system of receptors. According to this theory an effector cell that has been excited by directed impulses from original receptors is assumed to have its positive ions dissipated by that excitation. This dissipation leaves the cell negative. It then robs adjacent cells of the positive charge, leaving them in their turn negative. This process extends through the efferent cells, the connection system and the afferent cells, to the receptors. If a substitute stimulus is functioning simultaneously, there is a tendency for the negatively induced excitation to "drain" into the substitute afferent system. Hence, later, when the substitute

stimulus is present in the absence of the original stimulus, the phenomenon of conditioned response occurs.

Johnson's theory has many points in its favor, despite the fact that it is hypothetical. It is based upon scientific evidence drawn from physics, chemistry, neurology and physiology, as well as psychology. It accounts for most of the problems involved in learning, even the vicarious function of the brain. It needs further experimentation, however, for its validation. It supplements and strengthens Kapper's theory as an explanation principle.

c. The Theory of Cason.—Cason[1] has discussed the physical basis of the conditioned response with a view to showing the various factors which are probably operative within the nervous system in associative learning. He, like Johnson, assumes a change, an orientation of molecules in the membranes of conduction cells which makes possible the transmission of nerve impulses. He further indicates that there may be gross movement of nerve elements toward each other, thus enabling more rapid formation of associations; this covers a point of weakness in Kapper's theory. This movement may be facilitated by electrical attraction, due to the massing of charged ions on the surface of the membranes. He calls attention to the noticeable swelling of the nerve cells, due to decreased surface tension. This phenomenon is attributed to the operation of certain known laws of colloidal chemistry within the cell body, a condition considered favorable to passage of nerve impulses from one cell to another. Although not conclusive, the statement by Cason is suggestive of what may take place in the formation of associations.

d. The Theory of Lashley.—The significance of Lashley's theory[2] may be made clearer by describing briefly the experimental work upon which it is based. His method consisted in training rats to go through various problem situations including

[1] Cason, H., The physical basis of the conditioned response, *Amer. J. Psychol.*, 1925, **26**, 371–393.

[2] Lashley, K. S., *Brain Mechanisms and Intelligence*, Univ. of Chicago Press, 1929.

mazes of varying degrees of complexity. Learning was measured in terms of total trials, time and errors preceding the attainment of an arbitrary number of errorless responses. Certain parts of each rat's cerebral cortex were surgically removed, and the effect of the deprivation was measured (1) upon the animal's ability to *learn* given problems, or (2) upon its *retention* of habits that had been learned prior to the operation, this to be measured by rate of relearning. Thus it was possible to compare efficiency in learning of rats before and after lesions were made in the cerebral cortex.

In addition to studying the general influence of cerebral destruction upon learning and upon retaining, various special problems were considered. An attempt was made to determine the influence of the locus and magnitude of the injury upon the capacity to learn. After it had served its purpose as subject, each animal was killed and the brain examined in serial sections according to a standardized method of recording the location and magnitude of the lesions. The extent of injury averaged 31.1 per cent of the total surface area of the cortex with a range of 1.5 to 81.2 per cent. The distribution of injuries covered every part of the cortex, in one animal or another.

Massed records showed that the operated rats were strikingly inferior to normal controls. In one of the most complicated mazes the operated animals required approximately six times as many repetitions as normals. In retention there was an even greater difference between the operated and normal groups. The operated rats were distinctly inferior to normal rats in learning and retaining for several types of tests, the only exception being the formation and retention of brightness discrimination habits, in which there was little difference. In general, the more complex the maze, the more marked the inferiority of the operated animals.

Lashley's findings regarding the influence of locus of cerebral injury are significant in view of the emphasis in much current literature upon the importance of various motor and associative brain areas in learning. This part of the investigation involved the partial destruction of such cortical centers as auditory,

somesthetic, motor and visual areas to determine the influence of the locus of injury upon efficiency in learning. He showed that in some problems retardation is produced by injury to any part of the cortex, and that the amount of retardation is approximately the same for equal amounts of destruction. In fact, there may be a general retardation in learning produced by any injury and a specific retardation which may result from sensory deficiency, associated with lesions in a particular cortical area. In general, however, *the extent of the injury appears to be important while the locus is not.*

To show more clearly the influence of the extent of cortical injury, correlations were computed between the extent of injury and the number of repetitions required for original learning as measured by time, trials and errors. The results showed that, with the exception of the retention of one maze, the coefficients were positive and indicated clearly that there was a significant relationship between the extent of injury and the amount of practice required. His findings also showed that loss of the habit was far more frequent in cases with extensive lesions than in those where a smaller area was involved. Correlations between the percentage of destruction of the cortex and the scores for relearning indicated that there was a close relationship between the amount of injury and the degree of retention.

As a check upon this finding he sought to determine whether this relationship was constant for the entire cortex or characteristic of only some parts of it. He classified his cases according to the principal cortical areas, including frontal (motor), lateral (somesthetic overlapping the auditory area), occipital (visual) and parietal (transitional area overlapping all the chief histogocial areas) types, and computed correlation coefficients between the relearning scores and the amount of destruction. These coefficients were positive, ranging from 0.29 for trials in the occipital area to 0.88 for trials in the parietal area. On the basis of these findings Lashley concluded:

It is certain that the maze habit, when formed, is not localized in any single area of the cerebrum and that its performance is somehow condi-

tioned by the quantity of tissue which is intact. It is less certain, though probable, that all parts of the cortex participate equally in the performance of the habit and that lesions of equal size produce equal loss of the habit, irrespective of their locus.

Lashley proposes a theory based upon mass function and the operation of some general dynamic force or nervous energy, the exact nature of which he is unable to determine. His objections to existing theories of neural mechanisms that involve cerebral localization, reflex activity and dynamic force may be set forth under his four categories: (1) reactions are made to patterns of stimuli—"ratios of excitation"—acting upon many different types of receptors, rather than to isolated stimuli (with this must be included the fact that many cerebral areas and association tracts are active in a single experience); (2) destruction of tissues, especially when the balance in functioning tissue between the two hemispheres is disturbed, does not cause specific loss of function; (3) efficient learning and retaining, and less certainly ease of performance, depend rather upon the quantity of functioning tissue than upon any specific locus; and (4) the possible complexity of organization is apparently dependent upon the total quantity of nervous tissue. "These phenomena all point to a functional organization independent of differentiated structure and to some more general energy relations within the central nervous system."[1] The exact nature of these relations has not yet been determined.

Similar problems are found in biology in a study of the processes of growth and regeneration, a circumstance which leads Lashley to conclude that in the history of the development of biological forms may be found suggestions concerning neural organization. Studies by Kappers[2] and Child[3] indicate axial polarization evidenced by galvanotropic and galvanotactic phenomena,[4] and the operation of physiological gradients

[1] *Ibid.*, 166–167.

[2] KAPPERS, *op. cit.*, 270.

[3] CHILD, C. M., *Physiological Foundations of Behavior*, New York, Holt, 1924.

[4] Organisms have been found to orient themselves—behave as a compass—with respect to the polarization of a galvanic current passing through the solution

involving differences in rate of metabolic reactions.[1] Both axial polarization and physiological gradients indicate the operation of some general rather than specific neural energy. These gradients Child considers as "the primary indications of the existence of axiate patterns" and evidently responsible for their existence. Lashley[2] attaches great importance to these gradient systems:

> . . . The course of development seems to involve an ever increasing complexity of interacting gradient systems, becoming more delicately balanced and plastic with each step in structural differentiation. It would be strange if these mechanisms, which contribute so largely to structural organization, should cease to function with the completion of gross development. Rather, we should expect to find them assuming a role of greatest importance in coordinating the activities of the matured organism.

Lashley's conclusion from his own experiments is that response is made over a final common path to a pattern of excitation, irrespective of location, rather than to specific excitation of single and unalterable receptors. He terms this phenomenon reaction to "ratios of excitation," that is, "ratios of intensity of excitation" and "ratios of spacial extent or temporal distribution." He assumes that the unit of neural organization is the "mechanism, whatever be its nature, by which reaction to a ratio is produced." Such reaction he assumes may be due to the "responsiveness of the final common path to ratios of excitation or to a gradient of excitation between two or more adjacent neurological fields." If this ratio is altered or reversed, a corresponding change or reversal of potential difference will occur in the cortical centers and reaction will be made to this new relationship. Otherwise the "polarization and the steepness of gradients will remain constant, in spite of considerable alterations in the absolute positions of the centers of excita-

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in which they are contained. The growth of plants is affected similarly, indicating in both a corresponding polarization of the neural axis.

[1] The nervous system increases in fineness of structure and in rate of internal growth from the lower to the upper ends—posterior to anterior—an increasing steepness of grade in structural development and activity. This is indicated both in rate of development and rate of deterioration.

[2] Lashley, *Brain Mechanisms and Intelligence*, p. 167.

tion." Reaction is a response to the ratio of excitation, is dependent upon mass, rather than locus, in the functioning cortex and is due to some dynamic force in nervous activity. The truth or falsity of such a theory must await further experimentation which Lashley considers not difficult to perform.

These theories by no means exhaust the attempts to explain neural functions and structures involved in learning; they are cited to illustrate typical theories and to show the trend in the study of the neural basis of learning. Lashley[1] has called attention to other theories including the "increase in conducting substance as a result of exercise," supported by Verworn, Ziegler and others, and the "persistence of excitatory processes" by Ebbecke. These are classed with Kappers, Cason and Johnson as speculations which have been made concerning the nature of the engram or memory trace. Lashley considers drainage and irradiation as theories which attempt merely to account for the initial passage of impulses.

B. Psychological Bases of Learning

It was stated at the beginning of this chapter that the learning process may be studied through the systematic observation of the behavior of an organism. The preceding discussion clearly indicates that for the present little may be expected from neurology to clarify the understanding of behavior. The reason for such a condition lies in the fact that an organism cannot well be subjected to the sort of experimental study required for adequate understanding of its structure and function at the same time that it is being observed for its behavior. Until such accommodation can be made, it will be necessary to remain outside the organism and interpret the learning process—acquisition and retention—as a result of stimulus-response activities, by means of carefully controlled study with both natural and artificial situations.

Reliable data on learning have been derived from objective study of learning situations. Better methods are needed for carrying forward study under conditions that more accurately

[1] Lashley, (In) *Foundations of Experimental Psychology*, 557–560.

measure real and total learning situations. Experimental investigations are primarily concerned with the effect upon the learning process of variations in the stimulus situation and variations in the learner. These investigations seek to create situations wherein that variable, the effect of which the experimenter desires to measure, is functioning, while others are either eliminated, held constant or evaluated. The experimental factor may be, for example, auditory or visual modes of presentation, variations in stimulus situation, or it may be age or intelligence, variations in the learner.

1. Methods of Studying Behavior.—Hunter[1] has suggested that since acquisition is cumulative, it is best understood through the retention of previous stimulus-response activities. He enumerates three lines of evidence for retention: (1) a response may be reinstated by presenting the stimulus that originally elicited the response; (2) recognition of the original stimulus, although the response may not be reinstated; or (3) the response may be relearned in much shorter time and with fewer errors than originally learned. In measuring retention it should be kept in mind that one is measuring the results of acquisition, and thus the degree and quality of learning.

Techniques have been devised with reference to that phase of learning which it is desired to measure, including the effect of a certain type of stimulus or of some difference in the individual. These techniques include the maze, the problem box, puzzles, objective tests and various types of problem situations. Lashley[2] used the maze, the problem box, the inclined plane and brightness discrimination in his study of rats. Garth[3] employed riddles, Kline and Mather[4] puzzle boxes, while Cason[5] used nonsense syllables and meaningful materials.

[1] HUNTER, W. S., (In) *Foundations of Experimental Psychology*, 564–565.

[2] LASHLEY, *Brain Mechanisms and Intelligence*, Chap. 3.

[3] GARTH, T. R., The psychology of riddle solution: an experiment in purposive thinking, *J. Educ. Psychol.*, 1920, **11**, 16–33.

[4] KLINE, L. W., and J. E. MATHER, The psychology of puzzle problems, *Ped. Sem.*, 1922, **29**, 269–282.

[5] CASON, H., Specific serial learning, a study of backward association, *J. Exper. Psychol.*, 1926, **9**, 195–227.

Investigators have shown wide versatility in devising techniques adapted to the measurement of a variety of factors in learning. The measurement of mental functions is rapidly becoming more reliable, and there is now sufficient objective evidence to warrant the formulation of working hypotheses that may be applied to schoolroom situations.

It should be noted that not all knowledge regarding the learning process is based upon objective study. Introspection has contributed its share in the development of hypotheses. This method is subjective and when used alone should be interpreted with caution. It may not be entirely eliminated, however, even in experimental study, but rather should be used to supplement objective findings. When it is desired to determine the experiences of the learner, information must be obtained from the learner himself. He "looks within" and asks himself questions concerning his own mental processes. Data which are gathered by the method of introspection, when compared with introspective records of other learners, may be considered as possessing considerable reliability. As stated before, this method is valuable in supplementing objective findings.

2. The Place of Consciousness in Learning.—The question of the value of introspection introduces the concept of consciousness. Whenever the reactions of an organism are purposive consciousness is implied. Purposiveness assumes previous experience which is directional in function. In an earlier section it was noted that certain reactions are not based upon experience. The simple reflex, for example, is obviously not a conscious reaction although the organism may be aware of it; and instinctive reactions, although they generally move toward ends, are not the result of experience and need not be regarded as conscious reactions. Consciousness is operative only when the organism is capable on the basis of experience of purposively modifying and directing its reactions toward some end. Conscious reactions may become unconscious or subconscious as a result of automatization. Consciousness may often function as a directing influence in aiding the organism

to make new adjustments to its environment until adjustment is correctly made, after which it may recede. Many reactions such as walking and writing were at one time under the direct influence of conscious control, but, having become automatized, they are executed without conscious direction.

Where consciousness, because of a lack of experience on the part of the organism, cannot serve as complete aid in making adjustments to new conditions in the environment, the organism must resort to trial-and-error methods. Random endeavor is the method of all lower forms of animal life and a common method of higher forms, including man. When one is confronted with a difficulty that has not been previously met, the first impulse is to try anything. Thorndike's[1] cats in the problem box are the classical illustration of this process. At first the cats clawed at the top and sides of the box and only by accident was the latch turned, which effected their release. During repeated training periods there was a tendency to concentrate upon the proper reactions until finally the box was opened on the first trial. The method is obviously wasteful and slow. Education should eliminate as much as possible the element of random endeavor in the learning process by providing sufficient guidance and background to aid the pupil in reaching an early solution of problems.

Most explanations of learning (to be canvassed in the following chapter) deal with selection and elimination of random activity, which is often, though not always, a conscious affair. Since the trial-and-error method is universal, it is important to know how errors may be eliminated and successful responses retained. There is a difference of opinion among investigators as to the relative importance of elimination and selection. There is a tendency, however, to emphasize selection of successful responses and fixation of effective behavior. The school should guide the individual in making wider use of conscious direction in the solution of problems. It will probably never be possible nor perhaps desirable to eliminate

[1] THORNDIKE, E. L., Animal intelligence, *Psychol. Rev. Monog.*, 1898, **2**, No. 8.

entirely the element of trial and error but it may be possible to aid the individual in selecting successful responses.

C. Summary

Learning may be generally stated in terms of change which occurs between stimulus and response. Irrespective of the theory accepted, it must be recognized that in experience there is an awareness of certain sensations termed stimuli that elicit some sort of response. Learning involves improvement in ability to respond to stimulation.

When studying learning according to the neurological approach, there is an attempt to account for what takes place within the nervous system between stimulation and response. It is assumed that before learning can take place there must be formed a complete circuit within the nervous system between the point of stimulation and the response mechanism. The part played by the receptors with their afferent functions, as well as the efferent paths and effectors, is fairly well established. However, the exact nature of the nerve impulse, whether electrical or chemical or of some other nature, is a matter of conjecture. The function of the central nervous system is to organize afferent impulses and to direct them over efferent paths to the reaction system, although it is not understood how the connection is made. The difficulty lies in the explanation of the functioning of the central nervous system, about which several theories have been proposed. The neurological theories which have been formulated to explain learning may be considered supporting assumptions and at present little may be expected from neurology to clarify the understanding of behavior.

The learning process may best be understood through systematic study of behavior. When learning is studied according to the psychological approach, there need not be assumed any particular neurological change because our knowledge of neural physiology is limited. For the present at least the learning process is best interpreted in terms of

stimulus-response activities by means of controlled study with both real and artificial situations. Although introspection is subjective, it may be used to supplement objective methods of studying behavior. Consciousness is implied whenever reactions are purposive, and serves as a directing influence in making new adjustments.

CHAPTER V

EXPLANATORY PRINCIPLES OF LEARNING

A. Theories of Learning

Evidences of learning have always been observed, and many theories have been formulated to account for the learning process. Every theory of learning is evolved through a process which is dependent upon the intellectual and experimental background of its author. Most theories attempt to explain how successful responses are selected and unnecessary and erroneous responses are eliminated.

Aristotle,[1] although not directly concerned with the problem of learning, proposed the principle of association. The principle of contiguity present in his work was stressed by St. Augustine.[2] The pleasure-pain theory was formulated in the latter part of the seventeenth century by Locke[3] who also stated two minor principles: attention (readiness) and repetition (exercise). Trial and error were proposed by Morgan[4] in the latter part of the nineteenth century. Although the works of Aristotle, St. Augustine and Locke were related to memory and ideas, their contributions have suggested learning principles upon which later theories have been based.

1. The Pleasure-pain Theory.—Locke adapted the pleasure-pain theory to the problem of memory and suggested that pleasurable ideas were more readily remembered. The philosophy of the hedonist was based upon the conception of mind as an entity separated from objects and ideas by a barrier.

[1] Warren, H. C., Mental association from Plato to Hume, *Psychol. Rev.*, 1916, **23**, 208–238.

[2] *Ibid.*

[3] *Ibid.*

[4] Morgan, Lloyd, *Introduction to Comparative Psychology*, London, Scott, 1894.

In order that these objects and ideas might enter the mind some factor must operate that could force the barrier. For them this factor was pleasure-pain. Although these early theories now appear antiquated, they have provided a basis for modern educational and psychological philosophies including the explanation of learning.

When trial and error became recognized as dominant factors in the learning process by Bain and Spencer, pleasure and pain were used to explain the selection of desirable and the elimination of undesirable responses. According to the theory pleasurable responses are strengthened and unpleasurable weakened. Carr,[1] however, observes that accepted acts are not all pleasant and those rejected are not all unpleasant. This observation, if true, invalidates this theory as a simple and complete explanation principle in learning.

2. The Theories of Hobhouse and Holmes.—Hobhouse[2] suggested that a response the result of which tends to confirm it is thereby strengthened, while an act whose result arouses an inhibitory response is thereby weakened. He cites the experiments of Morgan who found that chicks will at first peck at any tiny object, but eventually learn to discriminate between them as follows: if the object be edible (as a bit of egg yolk), when seized and taken into the mouth it will elicit further eating movements; but if the object be inedible (as a bit of orange peel), when taken into the mouth it will arouse ejecting movements. Now, the "further eating movements" or the "ejecting movements" will, Hobhouse states, become "assimilated" to the preceding pecking-at movements, strengthening or weakening them respectively; the tendency to peck at egg yolk will be established while the tendency to peck at orange peel will be eliminated. Hobhouse offered his explanation as a substitute for the pleasure-pain theory, these feelings being only the expression in consciousness of the confirmatory and inhibitory movements. It will be found, however, that the theory has

[1] Carr, Harvey, Principles of selection in animal learning, *Psychol. Rev.*, 1914, 21, 157–165.

[2] Hobhouse, L. T., *Mind in Evolution*, New York, Macmillan, 1901.

much in common with the later-developed conditioned-response theory.

Holmes[1] has developed a modification of the Hobhouse explanation, substituting the notion of congruity and incongruity between the original act and those following acts set up by the sensory consequences of the original. In essence it is much the same.

The tendency in the theories of Hobhouse and Holmes to reject the pleasure-pain theory as an explanation principle for learning and to apply the principle of association is important in the light of the assumption of the significance of the ultimate response. The confirmatory or congruous acts are associated with an ultimate response and with those responses that tend toward the ultimate.

3. The Theory of Thorndike.—Thorndike[2] approaches the problem from a different standpoint and explains by analogy, selection and elimination. He assumes a theory of neural connection and suggests certain "satisfiers" and "annoyers" as fundamental for adjustment to the environment and natural to the individual.

The basis of his reasoning is his conception of the neural process. He believes that the neurons and the synaptic junctions rather than the body as a whole are responsible for satisfying and annoying states. Bonds are formed between a stimulus and a response and this simple mechanism of connections forms the basis for all reactions. His *law of readiness* is stated thus: when a bond is ready to act, the passage of a nerve impulse over the circuit is satisfying; its absence is annoying; forcing a bond that is not ready is likewise annoying. It is essential, therefore, that the learner be brought to a state of readiness by the arousal of interest or by some means for creating the proper mental set.

The familiar law of use Thorndike compares to the physical law of growth by exercise. To use a bond strengthens it,

[1] Holmes, S. J., *The Evolution of Animal Intelligence*, New York, Holt, 1911.

[2] Thorndike, E. L., *Educational Psychology, Briefer Course*, New York, Teach. Coll. Columbia Univ.. 1915.

while disuse weakens it. This law suggests the principles of use and disuse incorporated in his *law of exercise*, which may be stated as follows: to exercise a modifiable connection between a stimulus and a response strengthens the connection; not to exercise a modifiable connection during a period of time weakens the connection. This law is a good description of the results of exercise. It gives an account of the "stamping-in" process after selection has been made, but it does not designate *what* is to be exercised.

Thorndike further proposed the *law of effect*, which takes into account the satisfaction and dissatisfaction which accompany responses. The exercise of a modifiable connection between a stimulus and a response produces certain satisfying and dissatisfying effects. Other things being equal, when the effect is satisfying the connection is strengthened; when the effect is dissatisfying the connection is weakened. The law is supposed to account for selection and elimination in trial-and-error learning. Selection occurs as a result of the satisfaction which accompanies responses.

While Thorndike's "satisfiers" and "annoyers" are more fundamental than are pleasure and pain, he has not altogether escaped the pleasure-pain philosophy. It cannot be doubted that certain responses are accompanied by satisfaction and others by annoyance, but it is doubtful if this theory can explain selection and elimination; rather, it brings us to the crux of the problem.

Thorndike's more recent statements[1] indicate that he has not materially changed his point of view, but that he has modified and enriched it. He persists in the belief that learning is connecting, but connection appears to be a somewhat different concept from that of his earlier statements.

> I hope that the sort of connection-system which I have described is more acceptable than the kind against which configurationists . . . direct their criticisms—criticisms from which I have profited and with which I often agree. . . . [2] The connectionist welcomes the labors of a Franz or a

[1] THORNDIKE, E. L., *Human Learning*, New York, Century, 1931.

[2] *Ibid.*, 130.

Lashley which cast doubt on certain theories of the localization of cerebral functions. . . . [1] The connectionist welcomes the factual criticisms of an over-simplified conduction system. The connectionist, indeed realizes the difficulties of explaining human nature as a system of connections between neurons. . . . The word *connection* has been used without prejudice concerning what physiological event or condition parallels or constitutes it. It is so far simply an expression of the probability that a certain S will be followed by a certain R. *Bond,* or *link* or *relation* or *tendency,* or any still more colorless word may be put in its place.[2]

It seems that the quality termed *belongingness* by Thorndike[3] is one of the most important determiners of the strength of connections between two events. He defines *belongingness* as that psychological condition that permits neuron pattern 1 to lead directly into neuron pattern 2. Thus, the paired stimuli, "twin-22," seem to possess the quality of "belongingness," while a number like 97 associated with "twins" will have no such characteristic. Thus, Thorndike shows that the ease of learning and more particularly retention are influenced by the degree to which learning materials are grouped in such a way as to enable the formation of associations and development of meanings. It appears that the repetition of two events in temporal sequence has little effect upon the connection between them unless there is a "belongingness" emphasized in the connections.

Thorndike has also modified his law of effect. He continues to believe that a satisfying after effect of a connection greatly strengthens the connection, but now recognizes that the negative side of the law is not well established. Punished connections appear not to be eliminated, which indicates that a wrong response once made is more potent than any punishment that may accompany it. Furthermore, not only does a rewarded response tend to be strengthened, but it tends to strengthen a wrong or punished response that may occur with

[1] *Ibid.*, 126.

[2] *Ibid.*, 7.

[3] Thorndike, E. L., *Fundamentals of Learning,* New York, Teach. Coll., Columbia Univ., 1932.

or near it. Learning is primarily a positive and not a negative process.

Thorndike continues to place much emphasis upon the laws of readiness and effect. It has not been his intention in viewing learning as connecting to leave the impression that it is atomistic or mechanistic. He expresses his regard for mental sets or dispositions, including the total active make-up of the person to support his position. "The influences which cooperate with the situation to determine the response are as complicated, variable, purposive and spiritual as the learners themselves are."[1] He apparently assumes the obviousness of purpose in learning. Purpose in learning is not obvious and needs to be stressed to give it the recognition which it deserves. He finds much in the Gestalt concept with which he is ready to agree and which he is willing to employ in describing learning.

Considering the part played by Thorndike's earlier theory based upon the S-R bond concept, his present position is of especial significance. It is indicative of what is occurring in the field. The best is being taken from all approaches and used to refine and enrich existing theories.

4. The Frequency-recency Theory.—Watson's[2] work was influenced during its early stages by the findings of Bekhterev and Pavlov on the conditioned reflex. He believes that the individual is endowed with the necessary neural mechanism for response and that new connections need not be formed. He maintains that modification of behavior is accomplished by selecting and fixing the proper existing neural connections. He objects to an "overflow" of "diffusion phenomenon" in the transmission of nerve impulses[3] because

> . . . the nervous system is not built to permit such functions. When a stimulus arises in a receptor there is just as orderly a progression of events then as later when the habit is formed, *viz.*, the stimulus is carried off along preformed and definite arcs to the effectors in the order in which the arcs

[1] THORNDIKE, E. L., *Human Learning*, 1931, 120.

[2] WATSON, J. B., *Behavior: An Introduction to Comparative Psychology*, New York, Holt, 1914.

[3] *Ibid.*, 259.

offer the least resistance to the passage of the current. This order may vary with variations in the sum of intra- and extra-organic stimulation. There is no formation of new pathways.

His particular criticism is against the law of effect, as implying an influence of conscious states on motor behavior; his attempt is to substitute other principles that have no implications about conscious states such as pleasantness—unpleasantness. With this background it should be easier to understand his principles of frequency and recency as explanations of learning.

Frequency implies that if several responses are made to a stimulus the response most frequently made will be retained. When a situation is met and there is no instinctive, ready-made response available and no response mechanism has been established, owing to breaking down of synaptic resistance by previous experience, the individual tries anything and everything, until the successful response is eventually made. With each successive meeting of that situation the same trial-and-error method will lead sooner or later to the same successful response; in the course of many trials this successful response will have occurred every time, while the many unsuccessful responses may or may not have occurred each time. Thus the successful response will have been made most frequently. Because it is the most strengthened by dint of frequency, it will become the normal response to that situation. Watson has waived the possibility of effect accompanying the successful response, and his position does not account for the elimination of the unsuccessful responses. He states that they are dropped and only those necessary to the consummation of the successful response are retained. He recognizes the possibility of other factors but does not include them in his theory.

Watson adds to frequency the principle of *recency*. If several responses are made to a problem situation, the one most recently made will be selected. However, he believes recency is less prepotent than frequency. If recency were a very strong factor, the successful response, always the last performed, hence the most recent, should be the first response in a

new trial, but it seldom is until after several training periods. Again there is usually too great a lapse between periods for recency to be potent as a selective factor, and the difference between the last and other responses is so meager as to be insignificant.

Critics have said that frequency and recency account for what occurs after modification of behavior has been effected but do not account for that which causes the modification. Recent developments in neurology tend to invalidate the basis upon which Watson's theory depends. Lashley advocates a "diffusion phenomenon" when he speaks of some general dynamic factor that functions through the mass of intact cortex. Frequency and recency are factors in learning, but describe the process rather than explain it. Telford[1] has found that there is an inverse relationship between recency of response and the likelihood of the same response occurring again. Both Peterson[2] and Kuo[3] have also developed experimental evidence which is inconsistent with the frequency-recency theory.

5. The Sensory-intensity Theory.—The frequency-recency theory has been accepted by Carr,[4] but he has added the principle of intensity to explain selection. Like Watson, he is opposed to the pleasure-pain theory on the ground that it is subjective and assumes that unpleasant responses are "pulled out by the roots" and discarded. Carr assumes that all responses are retained, but that some are strengthened and are, therefore, more likely to be aroused when a situation is presented.

Carr believes that frequency, recency and intensity operate in the case of a problem situation involving a simple series of acts which leads to a solution. When the successful act has

[1] Telford, C. W., The refractory phase of voluntary and associative responses, *J. Exper. Psychol.*, 1931, **14**, 1–36.

[2] Peterson, J., Frequency and recency factors in maze learning by white rats, *J. Animal Behav.*, 1917, **7**, 338–364.

[3] Kuo, Z. Y., The nature of unsuccessful acts and their order of elimination in animal learning, *J. Comp. Psychol.*, 1922, **2**, 1–27.

[4] Carr, Harvey, Principles of selection in animal learning, *Psychol. Rev.*, 1914, **21**, 157–165.

been performed, certain sensory consequences accompany it which are more intense in their nature than are those accompanying other acts. He believes that the only criterion which can be used to differentiate between successful and erroneous responses is the nature of the sensory effects which accompany certain responses. It is this sensory quality which is responsible for the choice and fixation of successful responses.

In the solution of the maze he observed that the movements along the correct path are more vigorous than those in the blind alleys.[1]

The true paths and the cul-de-sacs are to be distinguished from each other on the basis of the degree to which they impede or encourage the animal's activity. A blind alley is but a sensory obstacle or impediment to the animal's activity; it means hesitation, caution, investigation, or disastrous sensory consequences. The true path presents fewer obstacles; it offers greater encouragement to freedom, continuity, rapidity, and vigor of motor expression. The difference is merely one of degree. The blinds check, thwart, and suppress activity more than does the true path, while the latter encourages and facilitates activity more than does a blind alley. The principle of relative intensity is here effective; acts are selected or eliminated according to whether the sensory consequences tend to facilitate and intensify them on the one hand, or to disrupt and suppress them on the other.

Carr's statement of sensory intensity has for practical purposes the same meaning as Thorndike's law of effect. Whether the successful act is pleasurable, satisfying or intensifying, the principle is the same. The individual is in some way influenced by the achievement of success.

6. The Drive or Motor-set Theory.—In the theories thus far described there has been no consideration of what keeps the learner striving in the face of obstacles. For example, in Carr's theory the animal in the maze was driven to solve the problem by hunger. Food or some equally strong incentive is necessary to keep the animal in a state of activity. It would appear, therefore, that the purpose behind learning activity should be considered in seeking to explain learning. What

[1] *Ibid.*, 162.

keeps the learner striving toward the consummatory response, and how does this striving influence selection and elimination?

The chief exponents of the drive or motor-set theory are Kuo,[1] Perry,[2] Tolman[3] and Woodworth.[4] Since Kuo has based his work partially upon the experiments of the others, his presentation is typical. Kuo emphasizes the determining tendency that keeps the individual persistently active throughout learning. He makes a distinction between fixation of habits and the elimination of errors. He contends that elimination of errors is of greater significance in learning than fixation and he centers his attention upon this phase of the problem.

Purposiveness is in the nature of a drive (muscle tension or motor set) toward a principal response. When the hunger pangs have been appeased, there is no drive and no activity in response to a food stimulus. But when this state of equilibrium is upset, a series of activities is set in motion in an effort to reach food and restore equilibrium. That this is not purely a conscious state of feeling or "seeing the end" is evidenced by the rat in a maze. Movements are random if the maze is unfamiliar, but there is evidently a determining tendency which keeps the animal going until it reaches food.

The various subordinate acts are selected or rejected on the basis of their reference to the consummatory reaction and may be classified as ill-adaptive, excessive and essential. Kuo's data show that "the ill-adaptive acts will be eliminated sooner than the less ill-adaptive ones, and the more essential ones are often preferred."[5] In other words the order of elimination is in direct relation to the consequence with reference to the principal response. That which impedes is eliminated before that which secures release for the muscle tension. Kuo further states that, when reactions are too complicated for ready differentia-

[1] Kuo, *op. cit.*, 1–27.

[2] Perry, R. B., Docility and purposiveness, *Psychol. Rev.*, 1918, **25**, 1–20.

[3] Tolman, E. C., Instinct and purpose, *Psychol. Rev.*, 1920, **27**, 217–234.

[4] Woodworth, R. S., Dynamic psychology, (In) *Psychologies of* 1925, Clark Univ. Press, 1926.

[5] Kuo, *op. cit.*, 25.

tion between ill-adaptive, excessive and essential acts, the learner may resort to trial and error wherein recency and frequency serve as determining factors. The essential contribution of the theory set forth by Kuo is that a principal response or drive, a purposive goal, impels the learner toward the consummatory response.

This theory accounts for the persistency of activity in the individual until the consummatory response is effected or until it is given up as futile. It does not, however, address itself to the question of just *how* subordinate acts are selected or rejected.

This theory may be further criticized on the ground that it separates all purposive striving into segregated acts which must be dealt with as such; thus it implies a definite sequence. Seldom do two successive trials include exactly the same elements. There must be something behind the mechanical nature of the selective process here assumed which accounts for persisting activity even when, for example, the plan of the maze has been altered. The rat will go steadily forward toward the food over unfamiliar obstacles, even, as Lashley[1] has discovered, with a partial paralysis of the motor function. There must be some integrating function that obviates the necessity for going through the learning process from the beginning. Peterson's completeness of response theory offers a valuable suggestion.

7. Completeness of Response by Peterson.—Every learning situation involves many stimulus-response elements which influence the process when viewed as a whole. Peterson[2] recognizes these separate acts, but sees them, both inhibiting and reinforcing, as integral parts of a more or less unitary process, not solved each by itself but in its relation to the others. He compares the process to a stream of water flowing over uneven ground. Each little hollow is filled in its turn by

[1] LASHLEY, K. S., *Brain Mechanisms and Intelligence,* Chicago Univ. Press, 1929.

[2] PETERSON, J., Completeness of response as an explanation principle in learning, *Psychol. Rev.* 1916, 23, 153–162.

the onrush of the main stream. But there is always an overflow into other hollows where the main stream plunges after filling the first hollow. "There is a continuous overlapping of responses some of which are in opposition while others are mutually helpful and serve the main response as additional stimuli, the latter leading to a more easy and complete response."[1] In this analogy and its application may be seen Peterson's conception of reactions as overlapping and not separate, independent movements. He holds that those acts which facilitate complete expression are accepted, while those that tend to inhibit it are rejected.

This is made a universally applicable principle, whether the balancing of conflicts is conceived as the relieving of muscle tension in the motor responses or as "conscious choice" in the higher levels of learning.[2]

> Instead of being a process of merely combining a number of elementary unit reaction-systems by association or conditioning to use a term now in favor, learning seems to be fundamentally a smoothing out of conflicts among incompatible impulses aroused by a complexity of external circumstances of stimuli so that the organism can act in a somewhat unitary or consistent manner toward them.

The implication is that release from conflict permits of complete expression in the consummatory act, brings satisfaction and serves as a "pull" toward that act. Elimination is brought about by a continuous process of settling conflicts that tend to inhibit a complete response, the basis of settlement being the complete response rather than the separate impulses. Peterson's own application of his theory to maze learning serves to illustrate it.[3]

> In the case of the maze problem the animal, on entering a cul-de-sac or any other path, in fact, responds at first more or less incompletely, because all the subordinate activities involved cannot take place at once. If the animal's progress is soon checked in a blind alley, the animal is not seriously nonplused. Certain elements of the general response are tending

[1] *Ibid.*

[2] PETERSON, J., Limits of learning by trial and error, *J. Exper. Psychol.*, 1926, **9**, 54.

[3] *Op. cit.*, 1916, 155–156.

to drain into other alleys that may recently have been passed, thus partially dividing the animal's activity. These elements now prevail when the others are checked. Let us suppose that the correct path, A, has just been passed when the animal suddenly comes to the end of the cul-de-sac, B. The tendencies to respond to A are still surviving and now direct the impeded activity into this the successful path. If on the other hand the correct path has been chosen the first time, the distracting impulses toward B would have become fainter and fainter as the animal proceeded into A and would finally have faded away. . . . When the food is finally reached all the remaining delayed reactions, the tendencies still persisting, to go into other alleys recently passed, are relaxed—the act as a whole is complete.

8. The Conditioned-response Theory.—A radically different approach to the problem of learning began as a result of the work of Pavlov and Bekhterev on the conditioned reflex, the former working with conditioned secretion reflexes and the latter with conditioned motor reflexes. Symonds,[1] Smith and Guthrie[2] have interpreted this approach in America. Watson[3] and Lashley[4] based many of their learning studies upon the conditioned reflex. They followed Bekhterev in the initial stages of their work although Lashley later placed more emphasis upon the work of Pavlov. It is noteworthy that Watson and Lashley have come to widely divergent conclusions although starting with the same data. Watson placed emphasis upon the mechanical and specific nature of the reflex while Lashley's recent studies show that the nerve-path theory is not an adequate explanation.

Elimination is effected because of the inhibiting influence of the conditioned stimulus. The cat in the problem box approaches the slats and, finding them rigid, is repulsed. Upon seeing the slats again the animal is impelled toward them as

[1] SYMONDS, P. M., Laws of learning, *J. Educ. Psychol.*, 1927, 18, 405–413.

[2] SMITH, S., and E. R. GUTHRIE, *General Psychology*, New York, Appleton, 1924. Also GUTHRIE, E. R., Conditioning as a principle of learning, *Psychol. Rev.*, 1930, 37, 412–420.

[3] WATSON, J. B., The place of the conditioned reflex in psychology, *Psychol. Rev.*, 1916, 23, 89–116.

[4] LASHLEY, K. S., The human salivary reflex and its use in psychology, *Psychol. Rev.*, 1916, 23, 446–464.

before, but at the same time is repelled by them because of the former experience of being inhibited. The sight of the bars alone is thereafter sufficient stimulus to cause their rejection. According to the theory the inhibiting effect of the conditioned stimulus causes the elimination "one by one" of the "movements of approach to the various confining surfaces of the box—until at last the animal is attracted to the door-opening device."[1] All surfaces are eliminated in this manner except the mechanism for release. "Approaching the button and approaching the open door are the only approach responses that are uninhibited by conditioned avoidance responses and while the door is closed the button alone calls forth an uninhibited response."[2]

This theory affords a very simple and readily understood principle for explaining the process of elimination. It has been suggested, however, that response is not made to separate elements in a situation, but to the whole situation. It has also been suggested that the neural mechanism is not so simple as that assumed by the proponents of the conditioned reflex. The fact of conditioning cannot be doubted, but the basis for explaining the conditioning may not be considered as a simple neural pathway and a chain of reflexes. Conditioning may be due to some more dynamic function of the central nervous system. Thus far the conditioned reflex is more descriptive than explanatory.

9. Gestalt Contributions.—A comparatively new psychology has been developed in Germany which is termed the psychology of the "Gestalt." The term means "pattern," "configuration" or "structure." Its chief point of distinction is the manner in which it views the reception of stimuli. Stimuli appear not as separated elements but as a unified "field" rising out of a "ground." This principle may be illustrated by Köhler's figures.[3] The lines in Fig. 4 are parallel and the spaces between are of alternatingly equal area. The

[1] Smith and Guthrie, *op. cit.*, 125.

[2] *Ibid.*

[3] Köhler, Wolfgang, An aspect of Gestalt psychology, (In) *Psychologies of 1925*, Clark Univ. Press, 1926.

lines group themselves naturally into series of two with the line at the right standing alone. If one tries to group them so that the larger area is enclosed and the line at the left stands alone, it will be found to be very difficult. It can be accomplished with strain but as soon as attention is relaxed the former grouping will reappear. By changing the figure slightly as in Fig. 5 an entirely different reaction will be experienced. The only difference in the figure is the addition of the short horizontal

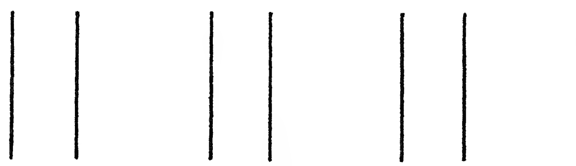


Fig. 4.

lines partially enclosing the larger area. It is now possible to shift the grouping almost at will.

The principle that Köhler intends to enforce is that the visual stimuli are not perceived as separated elements but tend to form patterns and assume meaning. A specific perceptual situation appears to compel a definite response. The conclusion is that perceptions should not be divided into elements for observation, but the perceptual experience should be studied

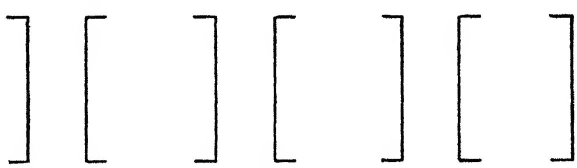


Fig. 5.

as a whole, since this is the manner in which all situations are actually received by the observer.

Black lines are drawn upon a flat white surface. There is no difference in the white after the lines are added except the lines themselves, but as one concentrates upon the figure that area between the lines which constitute a group appears to contain "something" that the surrounding white does not. Furthermore, that area appears to rise out of its "ground" and

stand forth as a "something" although there is no real difference between it and any other part of the white surface. By reason of a combination of two different principles, distance and enclosure, meaning has become attached. In Fig. 5 the elements remain the same but by shifting attention different areas on the surface assume meaning. It depends altogether upon change of perceptual attitude in the observer, rather than upon any change of the stimuli.

The principles developed by the Gestalt school in connection with their notion of "insight" are perhaps of greater significance for the psychology of motor learning or skill than those just described in the field of perception. Stressing the importance and unique quality of the situation-as-a-whole rather than its component parts, of functional analysis as opposed to structural analysis, the "configurationists" have attempted to extend the concept of Gestalt to include instinctive behavior, learning on all levels of intelligence and heredity and environment. They have also extended it to biology and to the physical sciences. Since their assumptions in the field of learning are to a considerable extent based upon the data derived from Köhler's work with apes, a brief exposition of his experiments is in order.

Köhler[1] presented apes with new situations containing problems pressing for solution. He made sure that the situations were within the animals' mental grasp, and that mere chance could not enter as a factor in the solution. Thus Sultan, one of the chimpanzees, was taken into a room of the monkey house by the experimenter, who opened the shutter of the window, threw out a banana and quickly closed the shutter again. Sultan could not see the banana fall. It was impossible for him to gain access to it through the window. Unhesitatingly he went toward the door of the room and pushed it open, went through the corridor to another door leading to the outside, opened this second door and walked directly to the spot where the banana fell. Although the problem itself was new to him, Sultan knew "the lay of the land" from previous experiences; therefore, a roundabout route was available in memory, if not

[1] Köhler, W., *Mentality of Apes*, New York, Harcourt, Brace, 1926.

in immediate perception. It is hard to deny that, since the detour was made unhesitatingly in one continuous motion, the animal had some "insight" into the situation. It is interesting to note here that Köhler observed marked individual differences in time of solving and ease of learning among the various apes studied. A similar experiment performed with a dog resulted in one trial and error, a few moments of hesitation, then a complete change of behavior and an unbroken movement to the objective.

Köhler then complicated the situation for the apes by constructing a setup necessitating the use of auxiliary objects in attaining the objective. A banana was placed near a cage, just outside the occupant's reach. Within the cage, somewhat to one side, were several sticks. The ape tried to reach the fruit with her hand, failed and lost interest. She made one or two additional attempts, then seemingly gave up. After waiting a half-hour, the experimenter allowed several other chimpanzees to approach the objective. Suddenly the ape leaped to her feet, seized one of the sticks and, immediately placing it on the farther side of the fruit, pulled it toward her. All of the apes improved in the use of sticks and other implements during the course of the experiments, but in practically all cases the improvement manifested itself in episodes in which sudden changes of the total behavior appeared. These abrupt changes of demeanor and consequent short cuts to success suggest flashes of insight. Later, more complex tests were made in which the handling of the objects, the construction of implements and even an elementary form of engineering were involved in attaining objectives. According to Gestaltists, Köhler's experiments prove that relatively sudden "intelligent" acquisitions occur typically in learning. These acquisitions are accounted for by "insight" or a sudden mental transformation of a situation perceived by the learner.

A more complete discussion may be found in the series of articles on "The Psychology of Gestalt" by Helson[1] and in the

[1] Helson, H., The psychology of Gestalt, *Amer. J. Psychol.*, 1925, 36, 342 (first in a series).

writings of Koffka.[1] A clear application of the principle to the psychology of learning has been made by Ogden.[2] It may be argued that there is no essential difference between the point of view stated above and that which has been stressed throughout the previous discussion of theories, namely, that response is made to a situation rather than to specific stimuli as such. This is only relatively true since the concept of configuration introduced by Gestalt psychology gives to sensation a significance and quality entirely different from that of current psychology. There is a close relation between the "ratios of excitation" of Lashley and the Gestalt point of view. These circumstances indicate that the modern trend in psychology is toward some concept akin to the unified field. It is pertinent to cite Ogden's explanation of the Gestalt as it relates to learning.[3]

According to the Gestalt view the process of learning, though it has differential aspects, is all of a piece. Being all of a piece means that any description, whether psychological or physiological, of the figure of behavior which is being learned must emphasize what Lashley calls ratios rather than a summation of entities, be they conscious contents or the parts of a biological machine. Learning takes place not as a compulsory response repeated until it is stamped into a habit, but as a dynamic interplay of forces which excite and thus disturb the equilibrium of the organism. The organism accommodates itself by a redistribution of its inherent energy. This is the meaning of "closure," the search for an appropriate end or solution to the problem that is being learned. But closure is not a vitalistic concept. The purpose of the act does not serve as an extraneous guide to behavior; instead an intrinsic urgency selects a proper course because the right ratios of behavior are prepotent over the wrong ratios.

The Gestalt psychology is by no means entirely new. Similar conceptions may be traced as far back as Aristotle. The Gestaltists themselves admit that extensive experimental work remains to be performed before they can fairly claim to have established their concepts on a scientific basis. Meantime, their school has provided a fresh impetus to the science of psychology

[1] Koffka, K., *The Growth of the Mind*, New York, Harcourt, Brace, 1925.

[2] Ogden, R. M., The Gestalt psychology of learning, *J. Genet. Psychol.*, 1930, **38**, 280–286.

[3] *Ibid.*, 283.

and has served to reaffirm the validity of such current movements in education as the unified, integrated curriculum, mental hygiene and the emphasis on a socially integrated personality, and the necessity for creative and purposive responses on the part of the learner.

B. Some Characteristics of Learning

It would be extremely difficult at this stage in the development of experimental investigations to formulate a comprehensive theory of learning. In the place of certainty has come a serious effort to study the learning process anew. *A priori* assumptions are being questioned. Chief among them when the approach is considered is that of necessary consequences, assumed both in the doctrine that all learning is conditioning and in the doctrine that all learning is some degree of insight.[1] It has been claimed that when the significance of this assumption is understood there will be a change in approach.

It is impossible to predict with certainty what will occur when an organism is excited by a given stimulus under experimental conditions. This is true of simple reflexes as well as of higher-order responses. Clearly there is variability and plasticity in the simple reflexes. In many instances this fact has been observed during the automatization of higher-order habits. The principles of exercise, recency, frequency and the like are all based in their present form on the assumption of necessary consequences (if X is present, the Y necessarily follows). These principles are in themselves inadequate explanations of learning.

The more acceptable approach is from the standpoint of necessary antecedents which lead to probable consequences (without X, no Y; with X, Y possible). This assumption may be stated as follows: given certain conditions in the individual and in the learning situation, one particular response is more likely to occur than another. It will be noted that the emphasis

[1] Hughes, Percy, Cooperation or conflict in the study of learning, *Psychol. Rev.*, 1930, **37**, 350–360.

is shifted and a new basis is established for a theory of learning. The earlier assumption makes possible the use of the stimulus-response-bond formula in its existing form: a stimulus acts upon the receptors of an individual and a specific response is elicited. The slight variations are due to elements in the situation which cause a different set of established connections in the neural system to function. The product of this type of learning is a mechanized individual; and experimental data based upon behavior indicate that such an individual does not exist.

The new approach would compel a revision of the stimulus-response situation. The individual comes first in the series, followed by the stimulus situation and the response. This placing of the individual first in the series is in accordance with the assumption of necessary antecedents and accounts for variability and plasticity of movement as well as for the selective function in learning.

1. The Nature of the Impulse to Learn.—Why is the individual not docile in the presence of a stimulus situation? What causes him to attempt to adjust himself to the changing conditions of his environment? Why does he persist in his effort to overcome obstacles in the way of achievement? These are some of the questions that must be answered before the way learning takes place can be understood.

Rignano[1] has defined *instinct* as a tendency of the organism to maintain or restore its physiological equilibrium. In the living organism there is a purposive striving toward some more or less well-defined goal. The problem involves psychological cause and effect. For every effect there must be a cause. Behavior, an effect, has a cause. This cause is the purpose of the individual and, as Woodworth[2] points out, "there is no contradiction between the purposiveness of a sequence of actions and its being a causal sequence." Purpose is the effect of definite causes and also the cause of definite effects. Some-

[1] Rignano, Eugenio, *The Psychology of Reasoning*, London, Paul, 1923.

[2] Woodworth, R. S., Dynamic psychology, (In) *Psychologies of* 1925, Clark Univ. Press, 1926.

thing has occurred in the life history of the individual to cause purpose.

A common mistake is made in assuming that the individual is at rest when being studied to determine the behavior effects of a certain stimulus cause. No human being confronts a learning situation without clearly defined antecedent activity. Such activity is in the nature of a present purpose. For example, when "2" and "2" are presented to a child of ten his response will be "4." And if "3" and "4" are substituted his response will probably be "7" because "and" usually is taken to mean "add." However, if his class is in the midst of a review of the multiplication table, his response will be "12" because he is actively set for the elements of the multiplication table. His purpose is to multiply. The cause of this purpose is the fact that the class is studying multiplication. The purpose to multiply causes the response "12" rather than "7" because no other response fits the purpose. He must respond or be uncomfortable because the stimulus "3" and "4" has been injected into his purposive stream and caused it to be disturbed. The child's purpose is to multiply because it is the only means by which he can produce the desired outcome.

In this illustration it may be noted that the child is not at rest. He is mentally set for the elements of the multiplication table. He is responding with the class to a series of stimuli. Into this stream is injected "3" and "4." It is a meaningful situation and not a stimulus which demands a response. The stimulus merely serves to upset the equilibrium on the receptive side of the system; this disturbed equilibrium results in a response which tends to bring the system to a new equilibrium. It is this fact that keeps the individual persistently active. There is always an active purpose present which may or may not be definitely directed. There are usually disrupting stimuli directing attention to a situation which demands a response. The school can direct purposive striving of the individual and provide those stimulus-situations which will broaden and intensify his training.

2. The Nature of the Situation.—A situation demands a response and the individual with a purpose is ready to supply it. The situation has usually been defined in terms of separate and specific elements within the range of attention. Following the lead of the scientist, the psychologist has sought to analyze the situation into its component elements and has regarded these elements as separately stimulating the individual. To a degree this is what occurs: there are particular receptor cells adapted to the influence of certain stimuli and these stimuli can excite a nerve impulse only by acting upon their respective receptors; but this does not mean that the individual must react separately to each stimulus element in the situation. To illustrate: suppose one is confronted with the problem "$75 \div 25$." The elements are 7, $5 \div 2$, and 5. Reaction is not made to each element separately.

By using the same illustration as typical, it may be pointed out that the nature of the individual's impulse to learn will determine to a large extent the nature of the situation for that individual. The situation changes with different individuals and with transformations within the individual. A child in the first grade may recognize the separate elements involved and be able to name them except for the division sign, but a child in the sixth grade will see a problem with meaning, perceiving it as a unified whole. These differing reactions may be explained on the basis that the situation has meaning for some and not for others. Clearly the stimulus remained unchanged but the situation was differently received.

The situation may not be defined in terms of separate and specific stimuli, but in terms of patterns or configurations that assume meaning or signify something for the particular individual. No two individuals experience the same situation identically. Their experience of the situation is dependent upon intrinsic and extrinsic factors which change the meaning of the situation. This fact is highly important for education because it involves the problem of adequately presenting materials for learning and preparing the child to react properly to the materials.

3. The Nature of the Response.—A desired response may be more readily attained when appropriate antecedents are provided. This statement was made clear in the illustration employed in the preceding discussion. Whenever a goal is clearly defined the impulse to learn and strive toward the goal is accentuated. One fallacy of the stimulus-response conception of learning is that it places too much emphasis upon the stimulus and not enough upon the response. This conception would lead one to believe that, given a certain stimulus, a certain response will follow—a natural outcome of the concept of learning as a system of neural connections. The response is the all-important element. Stimuli are means to that end—ways by which the individual is stimulated to action. Nor do these stimuli arbitrarily control the individual. If one is deeply engrossed in study he will hear but not respond to the ringing of the telephone provided that he has been assured that someone else will respond to all telephone calls. But if he is expecting a call, no matter how much engrossed he may be, he will both hear and respond to the ringing of the telephone. In both cases the stimuli are the same. He does not respond in the first instance because the activity within him is intense and purposeful while the ringing of the telephone has no significance for him. In the second instance his activity is no doubt equally intense, but the threshold for the ringing of the telephone is lowered owing to anticipation and preparation for it.

It is obvious that the response desired is a most potent factor in determining which stimuli will be effective and which will be unnoticed. The purposive trend of activity acts selectively upon the multitude of stimuli present in every situation inhibiting some and admitting others. The probability of the consequences of activity is dependent upon the degree to which success has been attained in establishing necessary consequences for the activity. One individual says that for a number of years the mythical man in the moon could be distinguished whenever the full moon was viewed. But some one suggested the woman in the moon. After some effort the features of the woman could be distinguished, which brought forth the exclama-

tion, "It is queer I never saw that before." And it was with difficulty that the features of the man could be recalled. The desire to make the proper perceptual adjustments became active in order to facilitate the new experience. The desired response could be experienced by blocking out the stimuli that tended to elicit the wrong response. There was always an accompaniment of a shift in perceptual attitude. This shifting of configurations to facilitate response in keeping with purpose is a daily occurrence. The stimuli remain the same but the individual reacts to them selectively.

4. **Some Principles of Learning.**—From the preceding discussion some principles may be formulated.

a. Every individual comes to a learning situation with some persistent activity. The organism is constantly in a condition of unstable equilibrium and seeks to restore it. This is true of the most carefully controlled experimental situations as well as of those commonly met in life.

b. The equilibrated condition is the goal of all striving and the striving is the explanation of persistent activity. The nature of the goal which will restore equilibrium is dependent upon the nature of that which has caused the instability. These may be physiological causes such as hunger and sex or psychological causes such as problems in arithmetic or puzzles.

c. The end of activity defines the purpose which in turn directs the activity. The experience of the individual aids purpose in determining the activity that will lead to the desired end.

d. The situation with which purpose must deal in determining activity has significant value and meaning to the degree to which the individual has been prepared for and anticipates meanings in the situation.

e. The nature of the situation is determined by the purposive activity when the situation is presented. The elements in the situation induce activity but the individual selects those elements to which response will be made in accord with purpose.

f. Selection and elimination are affected by congruity and incongruity with purposive activity.[1] Congruity signifies that

[1] For experimental confirmation see Edna Heidbreder, An experimental study of thinking, *Arch. Psychol.*, 1924–1925, 11, 1–30.

the individual selects from his experience those configurations that promote purposive activity.

C. Some Factors Which Condition Learning

An attempt has been made to distinguish between the principles which explain learning and the factors which influence its economical development. For example, frequency and recency are not sufficient to explain learning, although they may be very important in influencing its development. The factor of effect may be significant in the elimination of errors but even when considered together with frequency and recency is not an explanatory principle. The laws of learning proposed by Thorndike have been accepted for a period of years without much question as to their validity. These laws have been chiefly established upon animal experimentation, and students of education have not been convinced that they would apply with equal force to learning in human beings. The study of animals forms the basis for background in learning methodology, but should be supplemented by more careful investigation with human beings of varying ages and degree of maturity before being given widespread application to education.

In the discussion which follows we are concerned with the general problem of how the individual will react when he is presented with a learning situation. When he is confronted with a situation he is likely to respond in accordance with certain laws or factors such as common elements, frequency, recency, primacy, effect and intensity.

1. Common Elements.—The term *common elements* means that reaction to any situation is dependent upon elements in past experience which are similar to those of the present. The greater the number of common elements, the more easily can the individual make adjustments to the present situation. This factor may be illustrated by an investigation of Esper,[1] who determined the degree to which students would react to words in both English and German which were of the same category.

[1] Esper, Erwin A., A contribution to the experimental study of analogy, *Psychol. Rev.*, 1918, 25, 468–487.

He found that in both languages words of a category were usually associated with words of the same category. Those words are associated which have been connected with the individual's past experience. A striking example is found in the case of those who invariably gave the opposed meaning to adjectives; for instance, when the word "good" was presented, the response "bad" was evoked because they were accustomed in everyday life to make the association between "good" and "bad."

Reed[1] found that association reduces the number of repetitions required to learn by as much as one-tenth to one-half, that retention is improved and that there is a greater amount of transfer from one type of activity to another. He further showed that associations based upon meaning are most easily learned and retained. Symonds[2] interprets the findings of Pavlov with the conditioned reflex as meaning that in learning to make associations the unfamiliar element should be presented first. For example, in learning words in a new language, words in the foreign language should be presented before they are given in the vernacular. The new and old should also be presented as closely as possible in time and space. To use the same illustration, the foreign word should be placed adjacent to its synonym, with the foreign word coming first if possible. He says "new words in a foreign language are more surely learned if they are associated with the best known English synonym; events in history are better remembered if they are associated with the most commonplace or familiar contemporary events." This point of view is confirmed by Cason,[3] who shows the uselessness of presenting two unfamiliar items as a pair.

It is the teacher's business to correlate old and new experiences and thus make materials meaningful to the learner. The

[1] Reed, H. B., Repetition and association in learning, *Ped. Sem.*, 1924, **31**, 147–154.

[2] Symonds, P. M., Laws of learning, *J. Educ. Psychol.*, 1927, **18**, 405–413.

[3] Cason, H., The relation between the familiar and the unfamiliar. *J. Exper. Psychol.*, 1933, **16**, 295–306.

most common methods are to use concrete materials, illustrations which are within the pupil's experience, and to associate new material with facts and principles with which the child is familiar. The more meaning the material has, the greater the basis for association and thus the larger the number of common elements. In certain types of rote learning there will necessarily be little opportunity for establishing associations, but even here the arrangement and length of the material favorably affect the ease of learning.

2. **Frequency.**—Frequency refers to the use or practice of a function to be improved and forms the basis for drill and review. Irrespective of the accepted theory of learning, frequency is a significant factor in the automatization of responses and the formation of habits. The term *disuse* is employed to characterize the atrophy of a habit as a result of the absence of frequency. Although frequency finds its greatest usefulness in the development of motor habits and in the acquisition of specific skills, it is necessary in all forms of learning and cannot be minimized, regardless of the degree to which school subjects employ understanding and problem-solving ability. It is frequency which makes information and ideas usable and practicable.

Although frequency is a significant factor in learning, its limitations should be noted. Cuff[1] studied the influence of overlearning on the ability to retain. The results show that there is no definite ratio between the number of readings made by students and the saving in work. After a period of 24 hours there was one reading saved out of three, or 33.33 per cent; when the materials were read four times after they were learned, the saving was 50.96 per cent; and when read 16 additional times after they were learned, the saving was only 22.77 per cent, and so on in decreasing amounts for additional reading. With dull children much repetition and drill are needed, whereas in the case of bright children there is less profit from additional practice. Bright children are able to see relationships and therefore form a larger number of associations.

[1] Cuff, Noel B., The law of use, *J. Educ. Psychol.*, 1929, 20, 438–447.

The greater the memory value of a given piece of material, the greater the need for repetitions. In subjects in which it is necessary to learn material to the point of exact reproduction, much drill is desirable. Repetitions are more effective when an interval elapses between each presentation of material for learning. When repetitions are distributed there is the possibility of forming a larger number of associations. Frequency to be effective must also be attended by conscious purpose and attention.

3. **Primacy.**—Thorndike[1] conducted a series of experiments with college and graduate students in which the exercise was to estimate the lengths of strips of paper which varied slightly in size. These strips of paper were presented one at a time and were arranged in random order on a table before the subjects. Six experiments were performed and the results of all show that an individual's second or third response to a situation may be as predictive of later responses as the first. Thorndike's conclusions from these experiments follow:

> It seems probable that the facts to explain how the doctrine of primacy was fabricated are better explained by two corollaries of the general laws of learning. The first is that, other things being equal, the stronger a connection is, the oftener and so the earlier it will show itself. *Being first does not* make a connection stronger but being strong makes a connection likely to be first. Let S1-R1, S1-R2, S1-R3, S1-R4 have strengths of 5, 2, 2 and 1 respectively. Then where S1 occurs R1 will be the first response five times as often as R4 will and also it will later occur five times as often.
>
> The second is that when responses are connected with situations to which there are no pre-existing connections of more than infinitesimal strength (as in some cases of learning the names of strangers, etc.), the first experience raises the frequency from approximately 0 to 1, the second experience of the same connection raises it from 1 to 2 and so on. The relative strength of the connection with its competing infinitesimals is raised to 1 to 0 by the first experience, and only 2 to 0 by the second experience. This is an effect of frequency caused by position and is allied to the facts of diminishing returns and overlearning. It is different from the alleged primacy effect.

[1] THORNDIKE, E. L., The influence of primacy, *J. Exper. Psychol.*, 1927, **10**, 18–29.

The principle of primacy appears to be a phase of the general law of frequency. However, Thorndike's conclusions do not limit the effectiveness of the principle that correct reactions should be formed during the initial stages of learning. It is more economical to begin a task by making correct responses than to make errors which will later have to be unlearned.

4. **Recency.**—Recency postulates that there must not be too long a time between learning and relearning. Symonds[1] points out that if a conditioned response is not practiced for some time its strength will be impaired. In this sense recency is the factor which makes learning permanent and forms the basis for frequent review and recall. Frequent reviews and recall must be arranged so that when the effects of repetition have become weakened there will be constant relearning in order that forgetting may be reduced. It is especially valuable in the types of materials where a perfect response is desired.

5. **Effect.**—Effect refers to the feeling accompaniment of response. In solving problems it may be said that the individual is positively affected by those reactions which lead to satisfactory solutions and negatively influenced by those which lead to incorrect solutions. The more satisfying the reaction, the greater the likelihood that it will be repeated, and the more annoying the reaction, the greater the likelihood that it will be avoided. Pleasantness and unpleasantness have the tendency of either stamping in or blotting out a response. In the school it is the custom to reward successful performance with praise and unsuccessful performance with reproof. It is true, of course, that the individual receives his own reward when he successfully completes a task and his own punishment when it ends in failure. Thorndike's recent experiments show that reward and satisfaction are far more effective than punishment and dissatisfaction. The greatest usefulness of the law of effect is in the formation of a basis for the development of attitudes and desires, which form the motivation of schoolwork. School tasks should be made pleasant and rewards should follow successful performance.

[1] SYMONDS, *op. cit.*

6. Intensity.—In general the more intense the stimulus, the more intense the response. Jersild,[1] who investigated the effectiveness of various forms of primacy, frequency and vividness, found that the most effective form of vividness in presenting material verbally is to point out important features connected with the lesson, so that the learner's attention is directed to specific items in the material.

Symonds[2] shows that the rate at which conditioned reflexes are established is dependent upon the strength of the conditioned stimulus. He says:

> In general school learning depends more than is usually realized upon clearness and vividness of stimulus. Much of the effectiveness in learning depends upon good light, clear print and good blackboard illustrations. The baby who is learning to respond to its mother's voice makes the learning more quickly if the voice is clear and distinct. A very strong conditioned stimulus delays the function of the reflex. The reason for this is that too strong a stimulus probably calls out other responses, often emotional, which may interfere with learning. For this reason light should not be blinding or a teacher should not shout out.

Although stimuli may be made intense by providing good illustrations, vivid portrayal of material and clear print, the most important consideration is that the teacher make those materials which are worthy of emphasis meaningful to the learner. To make materials meaningful is to point out important items and aid the pupil in perceiving relationships.

D. Methods of Learning

1. Trial and Error.—Trial and error are in some degree present in all kinds of learning from the simple motor skill of card sorting to the formulation of a theory in higher mathematics. Random endeavor in accord with the principle of necessary antecedents is the only method the individual can employ when confronted with an unfamiliar situation. The situation stimulates him to activity but it is without meaning for him. He must try first one and then another element in the

[1] Jersild, Arthur, Primacy, recency, frequency and vividness, *J. Exper. Psychol.*, 1929, 12, 58–70.

[2] Symonds, *op. cit.*

situation which most nearly harmonizes with his past experience. This effort must continue until the situation becomes unified and meaningful.

Selection and elimination will be made on the basis of whether or not the results of random activity contribute to or harmonize with the stream of purposive activity. Teachers should provide antecedents which will reduce trial and error. Provision must be made for a stream of purposive activity and the preparation of the learner for the situation to which he is to respond.

2. **Conditioned Response.**—The conditioned response is a form of learning. Its current explanation is to the effect that, when two stimuli are operating simultaneously or successively, a bond is formed *between* the conditioned stimulus and the response so that when, later, the conditioned stimulus is presented without the original stimulus it will elicit a response. In this form of statement the principle obviously has its limitations. It is altogether possible that the same response may be excited by more than one stimulus, as, for example, when the teacher gains the same response from pupils by raising questions or by blackboard illustrations. To broaden the statement: the individual may habitually respond to a given stimulus, but, if two or more stimuli are operating simultaneously or successively, *they* become integrated so that thereafter a substitute stimulus may serve to excite the response desired in the place of the original.

This theory of integration is more plausible than the current theory which holds that a new connection is formed between some peripheral point and the organ of response. It makes the central nervous system the seat of modifiability and is in accord with the neurological principles underlying the work of Kappers, Johnson and Lashley. There are several ways to solve any problem as evidenced by behavior experiments which indicate variability and plasticity. The conditioned response thus interpreted becomes more serviceable in a wider variety of situations, as in the case of responses that require more than one stimulus to excite them.

Another type of conditioning is that in which several responses may be elicited by one stimulus. Multiple responses may be either simultaneous or successive. An example of the first is the response made to the calling of your name—your turning in the direction of the speaker, looking at him and saying "What is it?" with perhaps other movements overtly expressed, not to mention emotional responses. An example of the second is the series of responses to the ringing of the telephone. Some may object that the series is due to the operation of chain reflexes, but the reflex theory presupposes inflexible connections. It is more readily explained as an integrated response due to a unitary stimulus since the purposive nature of the situation leads to answering the telephone. The initial situation demands the solution but purpose integrates an entire series of responses to supply it. This is what happens when one is solving a problem in arithmetic. The problem situation arouses a series of responses which culminate in solving the problem.

The explanation of conditioned responses as integration provides helpful suggestions for education. The possibility of integrating simultaneous or successive stimuli to elicit a unitary response suggests the possibility of making schoolwork more unified so that subjects may be related. The integration of responses capable of being aroused by one stimulus makes possible the development of versatility in children. They do not need to react according to a set pattern. The possibility of seeing more than one thing in a situation makes life richer and more wholesome. Man is far from being a machine and the flexibility of learning is one factor that helps make of him a purposive and creative individual.

3. **Learning by Insight.**—The Gestalt concept of learning by insight differs in fundamental respects from conditioned response and trial-and-error learning. One must bear in mind that in virtually all experiments of the maze type the subject is not in a position to survey the situation as a whole. Hence, trial-and-error behavior is the only type of active response available, and on this level of learning college sophomores do

not fare much better than rats. Similarly, where the problem can be perceived as a whole, but where the solution is beyond the mental grasp of the subject, no learning results. However, when both situation and solution lie within the field of perception, a sudden insight may supply the key to the correct response. Whether this response is or is not preceded by a certain amount of trial and error is immaterial, believe the Gestaltists, because the behavior attending upon the insight is entirely different from the uncertain movements of trial and error. Instead of random motor responses there is a definite, continuous, seemingly purposive reaction leading directly to the goal. This would tend to explain the frequently found precipitous drop in the curve of maze and puzzle-box learning. Insight, when it occurs, is characteristically accompanied by an "I've got it!" exclamation; the eyes light up, knit brows unravel, fingers snap. Comparable changes are observable in animals.

It would be unwise, however, for the student to assume that all learning may readily be explained in terms of a single principle or method. No one method yet derived covers satisfactorily all situations in which learning occurs. Moreover, certain aspects of mechanism, vitalism and Gestaltism are not necessarily irreconcilable. The student should be critical of the extreme claims of any one school, remembering that each probably has some valid contribution to make to learning in particular and to the advancement of knowledge in general.

E. Summary

An adequate explanation of learning for all problem situations would require a series of statements based upon many points of view. Until a comprehensive theory is formulated one must consider all suggested theories and evaluate them for their merits and limitations.

No individual comes to a learning situation without some persistent activity. The situation has significance for the individual in the degree to which he anticipates meanings in the situation. Those elements of response that accord with

the individual's purposive activity tend to be selected. The selection and elimination of responses are, therefore, determined by their congruity and incongruity with the purpose which the individual has in mind.

Factors which influence economy in learning include common elements, frequency, recency, primacy, effect and intensity. The law of common elements implies that one's reactions to any situation are influenced by one's previous associations and experiences. The law of frequency demands that in all learning situations there should be opportunity for drill and review. Its chief function is to fixate learning responses. Primacy appears to be a phase of the general law of frequency and does not possess enough potency in itself to have a specific function. "Being first does not make a connection stronger, but being strong makes a connection likely to be first." The law of recency indicates that there should not be too long an interval between learning and review. The effect or the emotional concomitant of response may be pleasant or unpleasant. When responses are accompanied by pleasantness there is a tendency for them to be repeated, while unpleasantness is likely to cause their avoidance. In general the more intense the stimulus, the more intense the response. The effectiveness of intensity is dependent upon the meaning which the stimulus conveys to the pupil.

Trial and error, which is the most common method of learning, is the only procedure which the individual may employ when confronted with an unfamiliar situation.

One type of conditioning postulates that the same response may be elicited by more than one stimulus. Another form of conditioning indicates that many responses may be evoked by one stimulus. When conditioning is interpreted in terms of integration rather than the assumed formation of specific neural pathways, it becomes more useful in a variety of situations.

Learning by insight postulates that the individual may suddenly perceive the key to the solution of the problem. This method is characteristic of highly intelligent responses on the part of the learner.

CHAPTER VI

IMPROVEMENT IN MOTOR LEARNING

The two preceding chapters have dealt with the neurological and psychological bases of learning and the theories which explain the learning process. Although improvement is implied in all learning experiments, there has been no attempt to show the improvement process as revealed by experiments conducted in the psychological laboratory or school. This and the two succeeding chapters will deal with improvement in learning of both motor and mental activities.

Examples of the school's activities which employ muscular movements are found in writing, drawing, cooking, sewing, athletics, physical education, pronunciation, singing and the manipulation of laboratory equipment. Many abstract subjects require motor activity for application and mental processes are measured on the basis of some form of motor response. Intelligence and educational tests are conducted through the medium of oral and written reports. The mind plans and the muscles put the plans into operation.

Muscular movements are dependent upon coordination between physical and mental responses and the ease with which skill is developed is dependent upon previous conditioning and development of muscular tissue. However, learning actually takes place only within the neurological centers, irrespective of the type of response. The term *motor learning* is applied to activities in which muscular responses predominate.

A. Types of Motor Skills

Muscular skills represent at one extreme simple acts which are closely related to reflexes and at the other complex responses which require several simultaneous operations and concentrated

thought. Different activities require the coordination of different muscles and varying degrees of concentration.

1. Simple Motor Processes.—Reflexes form the basis for the development of muscular skills. The first muscular activities involve the larger muscles, which control general bodily movements and posture as in walking, standing and stooping. Activities using these muscles are termed simple

TABLE 10.—SOME TYPICAL INVESTIGATIONS DEALING WITH SIMPLE MOTOR PROCESSES

	No. and age of subjects	Learning activity	Criteria of learning	Length of practice period
1. Broden (1924)	1 subject	Ball tossing	No. of balls correctly tossed out of 200 each practice	100 days
2. Gates and Taylor (1926)	5 to 8 kindergarten subjects each group	Tapping	Average score per day	111 days
3. Peterson (1917)	28 college students	Ball tossing	No. of errors per practice period	60 practice periods: 25 throws each practice
4. Ruch (1925) *a.*	120 junior-high-school subjects Superior group	Card sorting	Average score per days of practice	1 to 10 days
b.	120 junior-high-school subjects Average group	Card sorting	Average score per days of practice	1 to 10 days
c.	120 junior-high-school subjects Inferior group	Card sorting	Average score per days of practice	1 to 10 days
5. Trow and Sears (1927)	1 college student	Card dealing	Average no. of cards dealt per minute. All cards were dealt 6 times each practice	20 practices
6. Wilson (1928)				
a.	3 boys 9 years of age	Star tracing	Time required for each tracing	20 mirror tracings
b.	3 boys 9 years of age	Cylinder tracing	Time required for each tracing	16 tracings

motor processes because of their close association with original reflexes and their ease of automatization. Examples of these skills include ball tossing, lifting, carrying, tracing and card sorting. Such activities require little attention because of previously automatized movements. The analysis of studies in Table 10 illustrates the experimental work which has been made on such processes. These studies are analyzed according to subjects used, learning activity, criteria of learning, and the length of the practice period. For example, Broden, using one subject, studied improvement in tossing balls as determined by the number correctly tossed out of 200 each practice period for 100 days.

2. Complex Motor Processes.—Complex movements require the exercise of a large number of muscles operating simultaneously, as well as a fine coordination of the smaller muscles. The amount of mental effort necessary to attain skill in complex processes is also much greater than that required for simpler processes. Many of the complex activities require coordination of separate movements and a recoordination of these into still more complex responses. Playing a piano requires that the proper group of fingers be used on the keys with the correct amount of speed and force and this coordination in response to reading and interpreting the score must be readjusted continuously for each new combination of notes. Other types of complex skills include performing surgical operations, playing musical instruments, operating some types of machinery and scientific apparatus, typewriting and telegraphing. Typical illustrations of the complex processes are shown in Table 11. For example, Barton, using 15 subjects, studied improvement in typewriting according to the number of words written per minute for a period of 35 weeks.

B. Curves of Motor Skill

Improvement in motor skills is characterized by better coordination between mind and muscle and between muscle and muscle. It involves the selection and development of successful movements and the elimination of those that are

TABLE 11.—SOME TYPICAL INVESTIGATIONS DEALING WITH COMPLEX MOTOR PROCESSES

	No. and age of subjects	Learning activity	Criteria of learning	Length of practice period
1. Barton (1926) *a.*	15 subjects, Group P	Type-writing	Words per minute	35 weeks
b.	15 subjects, Group W	Type-writing	Words per minute	35 weeks
2. Bradford (1915)				
a.	Subjects K and B	Type-writing	Strokes per minute on letters	1 subject 87 days; other 118 days
b.	Subjects K and B	Type-writing	Strokes per minute on words	1 subject 87 days; other 118 days
c.	Subjects K and B	Type-writing	Strokes per minute on sentences	1 subject 87 days; other 118 days
3. Chapman-Hills (1916)				
a.	Subject A	Type-writing	Gross score minus errors	100 days
b.	Subject B	Type-writing	Gross score minus errors	105 days
4. Edwards (1923)	10 high-school subjects	Type-writing	Average no. of words per 5-minute period	360 hours of practice
5. Koch (1923) *a.*	45 college students	Piano playing	Errors per year of piano study; whole method	9 years
b.	45 college students	Piano playing	Part method	9 years
6. Perrin (1914) *a.*	Subject (C. N.)	Maze	Average errors	25 trials
b.	Subject (R. B. O.)	Maze	Average errors	32 trials

unsuccessful. The rate of progress in skills may be measured by the increase in proficiency per practice unit, by the decrease in the number of errors or by the reduction in time required for performance. Regardless of the method of measurement, the curve has essentially the same form. When the curve is

constructed on the basis of increased efficiency with continued practice, it indicates an initial rise with a gradual decrease in rate. There are also fluctuations and plateaus. The difference is not in the kind of curve but in the direction in which it moves.

1. **Types of Curves.**—Theoretically there are two types of curves, which are interpreted in terms of the degree of initial spurt. Convex curves have a rapid initial rise followed by a decrease in speed while concave curves have a slow initial rise followed by an increase in speed. Variations of these forms have also been observed.

Investigations indicate that curves of skill tend to assume a convex form. This condition is partially due to the fact that no skill is measured from its beginning. Measurement in walking a tight wire begins with the experiment. The curve does not take into consideration that the individual has already learned to walk, that the balancing act has been mastered during early childhood and that all that is necessary is for the subject to adjust previous conditioning to a new situation. No experiments have been conducted to account for this original conditioning and for that reason there is no absolute zero point from which to begin measurement. The rapid initial spurt with later decrease in progress may be partially explained on the basis of previously developed skill in similar movements. When these movements have been exhausted and new movements must be learned and coordinated with the old, there is a change of speed and often a marked fluctuation or plateau. It is probable that, were measurement actually begun with the formation of the first movement, the curve would approximate a combination of concave-convex form. When motor skills utilize movements and muscular coordinations already developed, the curve is likely to show a marked initial rise.

2. **Curves of Simple and Complex Processes.**—Curves may be compared on the bases of initial rise, the continuation of the curve and the frequency of fluctuations. Figure 6 represents a composite study of investigations made comparable

on the basis of percentages. The solid line represents a composite curve based upon nine studies of simple motor processes while the broken line represents a composite of 20 studies based upon complex motor processes. A comparative study

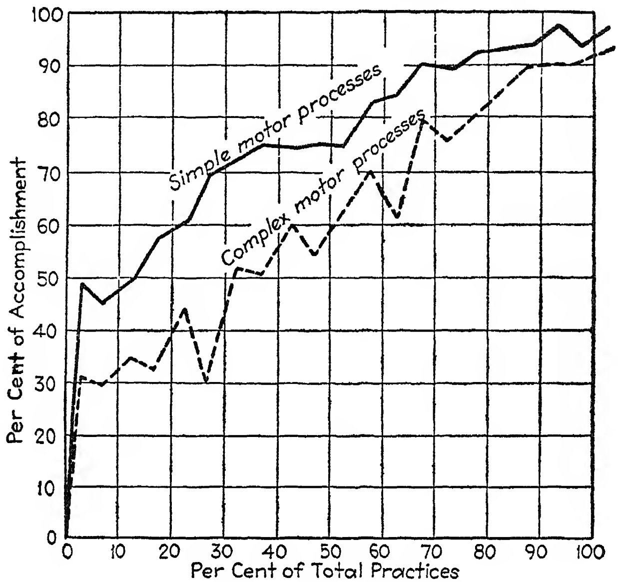


FIG. 6.—The full line represents a composite of 9 studies dealing with simple motor processes while the broken line represents a composite of 20 studies dealing with complex motor processes. The curves show the relationship between accomplishment and continued practice as expressed in terms of percentages. For example, during the first 5 per cent of the total number of practice periods there is a certain per cent of the total accomplishment for the study. The highest degree of accomplishment is represented by 100 per cent and the total number of practice periods (irrespective of number) is represented by 100 per cent.

of these curves indicates that the initial rise in the simple motor processes is much more rapid than that of the complex processes. The general tendency of these composite curves is confirmed by individual studies. When a curve is constructed on the basis of Broden's[1] study of tossing balls into a box, a very rapid initial rise is found during the first 10 days' practice, followed

[1] BRODEN, S. R., Extensive experiments in motor learning and relearning, *J. Educ. Psychol.*, 1924, 15, 313–315.

by a decrease after that time. At the end of 40 days the limit appears to have been reached and is followed by marked fluctuations.

Edwards[1] used 10 high-school pupils in an experiment to determine progress in typewriting. A record was kept of the average number of words written during a 5-minute practice period for a total of 360 hours of practice. When a curve is constructed on the basis of his results, it shows a fairly gradual rise during the initial stages of practice followed by gradual improvement throughout the remaining periods of practice. In the simple processes maximum height is sometimes reached with only a few trials, after which the curve assumes a more constant level, while in the complex processes it may require years to reach a high degree of skill. One may become proficient in card sorting within a few hours whereas it may require many years to become skillful in piano playing.

3. Characteristics of Curves of Skill.—Curves of motor skill are seldom steady. Their rise is irregular with intermittent advances and regressions. Plateaus may be found in both simple and complex processes. In complex processes plateaus and fluctuations are more frequent and consequently progress is slower.

a. Initial Rise.—The first rapid and continuous rise in any curve of motor skill is due to the fact that many coordinations are simultaneously made in many associated movements. The rapid rise is also influenced by previous experience of similar movements which have already become automatic. As long as there are possibilities for improvement in the readjustment of these coordinations the curve will continue to rise. The rise may continue with fluctuating periods of retardation until errors have gradually been eradicated and improvement becomes a matter of speed and application. In simple processes the initial rise may continue almost to the physiological limit and continued practice may produce little

[1] Edwards, W. G., *Improvement Curves in the Learning of Typewriting*, Toronto, Ryerson Press, 1923.

improvement, while in complex situations the initial rise may be very short and the physiological limit reached only after long and continuous periods of practice. Initial rises may also be due to the novelty of the situation and to additional effort due to interest and enthusiasm.

b. Fluctuations.—Fluctuations may be due to many causes. The waning of initial enthusiasm lessens effort and causes fluctuations. When there is fluctuation of attention and conscious effort, irregularity in the skill curve is noted. Muscular strain and fatigue also produce fluctuations. Conscious effort to minimize the effect of fatigue often produces marked improvement followed by a decrease in efficiency. Pleasurable feelings, nervousness and fear have varying effects depending upon their intensity. The emotional effect is dependent upon the individual and the intensity of the emotion.

c. Plateaus.—Plateaus are especially characteristic of curves of complex processes. They may be due to breathing places wherein the muscular coordination has reached its physiological limit and the limit may be raised only by means of further adjustment. A runner may reach a point in speed where his legs refuse to move more rapidly. The movements of the legs not only affect the muscles directly concerned but they also influence action of the heart, lungs and other internal organs. When these organs have become adjusted to the new motion, still greater speed may be attained.

Plateaus may also be caused by inhibitions in muscular coordination. Inhibitions may occur when another motion uses the same muscle or group of muscles in a different combination. They may occur when the mind is occupied with another combination or coordination different from that in operation, or when two separate and distinct operations are simultaneously attempted. Inhibitions may be caused by conflicting methods of practice, as in changing the style of writing. They may be caused by relaxation of effort and attention or by misdirected effort due to a misunderstanding of the problem. They may represent different levels of achievement in which one particular act has been mastered and it

becomes necessary to pause until a new coordination has been perfected before progress is resumed. A plateau may occur in typewriting when passing from one group of practice words or sentences to another.

Many pupils become discouraged in learning complex skills because of lack of ability or patience to continue practice until insight or recoordination makes the next rise possible. Plateaus vary in length and appear at different locations for different kinds of motor processes. They may be reduced by painstaking guidance and a sympathetic understanding of difficulties. By keeping the end in view and being aware of progress and the means by which it is made, discouragement, lack of interest and attention may be prevented. Critical periods in work may be prevented from extending into long plateaus by organization of details, by automatization of the necessary movements and by improved physical condition and mental attitudes.

d. Physiological Limits.—It is only when the mind has grasped the significance of short cuts and the elimination of useless motions that physiological limits may be raised. Physiological limits are also determined by the condition of the muscular tissue, and improvement in motor skills is dependent upon the adjustment required to produce the desired results. To reach physiological limits requires a degree of specialization that comparatively few attain. To continue practice and study in order that time may be reduced and that skill may be perfected with fewer movements requires diligent application that only specialists are willing to give. When muscles are pliant and flexible there is possibility of raising skills above the mediocre level as well as extending physiological limits in specialized study. Extreme emphasis upon development of specific skills results in a tendency toward inhibitions and muscle binding. The school should, therefore, provide opportunity to develop many skills and to specialize in a few.

C. Individual Differences in Motor Skill

1. Age.—Increase in age is accompanied by physiological maturation, better coordination, concentration, persistence and

more resistance to fatigue. Gould and Perrin,[1] using as subjects 15 children with an average age of 11.6 years and 25 adults and undergraduate students, studied individual differences in learning a finger maze and found that adults were superior to the younger group. This finding was based upon the number of original errors, their speed of elimination and progress in learning. The superiority of the adults was due to more effective application of intelligence and greater motor stability. The movements of the adults were characterized by slower motions, more careful memorization of directions and less repetition of blind pathways. Condée[2] compared elementary, high-school and college students on ability to learn a stylus maze. The high-school pupils made a higher record than did the elementary pupils, while the highest scores were obtained by the college group. Hicks and Carr[3] found that graduate students make better records in time and fewer errors on an outdoor maze than children from eight to thirteen years of age. Freeland[4] studied the effect of practice in learning to typewrite over a year's period and found that older children learned more quickly and retained longer than younger children; their learning curves also showed fewer fluctuations.

With increase in age there is within limits a corresponding increase in motor skill. Increase in age is accompanied by better adaptability, concentration and ability to detect and eliminate errors. Adults are especially superior in skills which require a wide range of experience and mature physical and mental ability. Children are probably superior in skills requiring physical plasticity such as acrobatic stunts and dancing. The child's superiority in some skills is due to his unconsciousness of self. In performing simple operations such

[1] Gould, M. C., and F. A. C. Perrin, A comparison of the factors involved in the maze learning of human adults and children, *J. Exper. Psychol.*, 1916, **1**, 122–154.

[2] Condée, B. H., The relationship of intelligence and age to efficiency of maze learning, master's thesis, University of Chicago, 1925.

[3] Hicks, B. C., and H. A. Carr, Human reactions in a maze, *J. Animal Behav.*, 1912, **2**, 98–125.

[4] Freeland, G. E., A year's study of the daily learning of six children, *Ped. Sem.*, 1921, **28**, 97–115.

as walking a wire, tossing shot into a glass or sorting cards there appears to be little difference between the adult and child, whereas in complex processes, where mental concentration, reasoning ability and organization are required, older persons have the advantage.

2. **Sex.**—Cummings[1] studied six women and six men to determine the effect of basketball practice upon the rate of voluntary movement, involuntary control, power of concentration and susceptibility to suggestion. The rate of motor development was tested by tapping, steadiness of motor control by the kymograph, the degree of attention by a cancellation test, and suggestibility by means of weight and line illusions. He found that men are superior to women in motor reactions, while women are superior from the standpoint of attention and are less susceptible to suggestion. Husband and Ludden[2] measured 30 men and 40 women on five tests, two of which were simple and three complex. They found that on some motor tests men were superior while on others the women excelled.

In muscular skills which require size and strength, boys appear superior to girls. Girls excel in skills requiring the coordination of the smaller muscles and close attention to detail. With the possible exception of difference in strength and muscular development, other differences are probably due to environment and training rather than to any innate differences in ability.

3. **Intelligence.**—Johnson[3] studied the relation between intelligence and skill, using as subjects the inmates of the New York Reformatory for Women. She selected her groups on the basis of results obtained by the Stanford Revision test and the Yerkes-Bridges point scale. One group represented the highest intellectual level, another the medium and a third

[1] Cummings, R. A., Effect of basketball practice on motor reaction, attention, and suggestibility, *Psychol. Rev.*, 1914, 21, 356–369.

[2] Husband, R. W., and M. J. Ludden, Sex differences in motor skills, *J. Exper. Psychol.*, 1930, 14, 414–422.

[3] Johnson, Buford, Practice effects in a target test: a comparative study of groups varying in intelligence, *Psychol. Rev.*, 1919, 26, 300–316.

the low or feeble-minded level. Skill was tested by javelin throwing. The highest group in intelligence ranked first in score, the middle group second and the feeble-minded group third. Performance of the highest and lowest groups was characterized by wide variability while that of the middle group showed little variation.

Bousfield[1] devised a series of geometric forms which pupils were required to duplicate with pen and ink. The study was based upon 180 children of the fourth, fifth and sixth grades. His results indicate a low correlation between intelligence and the ability to copy various geometric forms. Clinton[2] found that there is practically no relationship between mirror-drawing ability and intelligence. Johnson[3] concluded that intelligent individuals have the least difficulty in walking a tight wire. Fildes,[4] in an experiment in mirror writing, found that mentally defective children tend to repeat what they have done without criticism. They do not correct mistakes in writing and so become confused. Gates and Scott[5] concluded that, the relation between motor-speed performance and intelligence varies with the complexity of the motor process. When the motor problem involved mental direction, there was a relatively high degree of relationship between intelligence and motor skill.

Indications from these and other studies are that intelligence plays an important part in the development of motor skills. One of the functions of intelligence is to control and coordinate muscular activities. Skills of the simple type require a limited amount of mental coordination and direction and therefore bear little relation to intelligence. The simpler skills are primarily dependent upon reflexes and instincts where intelli-

[1] Bousfield, W. A., A study of motor skills in free hand duplication of geometric figures, *J. Appl. Psychol.*, 1930, **14**, 478–485.

[2] Clinton, R. J., Nature of mirror drawing ability: norms on mirror drawing for white children by age and sex, *J. Educ. Psychol.*, 1930, **21**, 221–228.

[3] Johnson, G. B., A study of learning to walk a tight wire, *Ped. Sem.*, 1927, **34**, 118–128.

[4] Fildes, Lucy G., Experiments on the problem of mirror writing, *Brit. J. Psychol.*, 1923, **13**, 57–67.

[5] Gates, A. I., and A. W. Scott, Characteristics and relation of motor speed and dexterity among young children, *Ped. Sem.*, 1931, **39**, 423–454.

gence and training are not essential. In the complex skills intellectual control and training are necessary. Complex motor skills, therefore, become an index to intelligence.

D. Economy in Acquiring Motor Skills

Efficiency in skill is determined by the time and effort required to produce successful responses and by the amount of automatization that is effected. Various factors contribute toward the economical attainment of success.

1. **Trial and Error.**—Trial and error is a process of learning by doing. No one knows what he can do until he has made the effort. Since success is the ultimate criterion for skill, the important consideration is to select those motions or coordinations which will produce the desired result. In every selective process errors are eliminated as they arise until some coordination is discovered that will produce success. This may not be the only or the easiest way, but if it proves successful it is accepted. The trial-and-error method thus consists in eliminating errors until a successful response is found.

Experience and reasoning do not eliminate trial and error, but they limit the field of operation and direct effort toward the most appropriate procedure. When a method has been selected, it must be tried out. Since there are many ways of reaching success, the method which is best suited to the individual may be the appropriate method for him. An error for one is, however, an error for another. By studying errors that have been made one learns what to avoid and has a better chance of selecting those responses which will produce satisfactory results. A knowledge of errors narrows the field of operation and prevents useless movements.

2. **Guidance.**—Guidance is primarily a process of limiting the field of action by preventing errors and by focusing attention upon those activities which assure success. Guidance may be administered by manual means, demonstration, instruction, explanation and criticism.

Manual guidance consists in what is sometimes termed putting the subject through the act. An example of its use

may be found in teaching young children to write. The instructor may direct the hand of the child through the motions of forming the letters. In the finger maze the experimenter may take the hand of the individual and lead it through the proper pathways. In teaching certain steps of a drill the instructor may turn the foot in the appropriate direction or place it in the correct position. For a few motor processes guidance by manual means may be used to advantage.

Guidance by demonstration consists in performing the act before the pupil and requiring him to repeat the performance of the demonstrator. This process is sometimes considered imitation. Imitation, however, must be considered only in a relative sense. Given a definite goal, the easiest way to attain it is by following the example of one who has already reached it. A teacher writes a copy on the black-board for a class in writing. Each child copies the pattern, yet none succeeds in making an exact duplication of it. Each copy shows individual characteristics which distinguish the work of one member of the class from the other. In guidance by demonstration the pupil interprets movements in the pattern in terms of his own movements and tries them out. By observing successful movements and reproducing similar coordinated movements, speed and accuracy are increased. Demonstration is found very effective in teaching home economics, athletics, writing, singing and pronouncing.

Instruction and explanation are the most common forms of guidance used in school. The teacher tells the pupil what to do and how to do it, or gives written assignments and directions. Written instructions should be very explicit and the explanations so complete that nothing will be left to chance. Definite instructions lead to the formation of correct habits. Oral instructions are more flexible because the instructor has the opportunity to judge from personal contact the amount of direction and explanation required, and may repeat or elaborate as the occasion demands. Because of its flexibility, adaptability and stimulation of interest, oral instruction is superior to written instruction and is probably the best single form of

guidance. Criticism consists in indicating successful movements and in suggesting methods for eliminating errors by substitution. According to its time of administration, criticism may prevent or correct errors.

In most cases demonstration, explanation, instruction and criticism should follow each other in the order named. Demonstration, explanation and instruction precede the pupil's attempt, while criticism parallels it with such repetitions of the first three as needed. Excessive or misdirected guidance reduces efficiency and thwarts originality. Redirected activity should be for the purpose of teaching the pupil to assume a critical attitude toward his work that he may detect and eliminate his own errors.

3. **Movements versus Objective Results.**—It is usually more economical to direct attention upon the result to be attained than upon specific movements to be made. Instructors may teach form but execution must be learned. Form is subjective, while results are objective and readily measured. It is possible to stress form to the detriment of execution. Parker states:

> Ordinarily the learner's attention should be centered on the objective results of the movement, not on the movement itself. An elaborate analysis of the movement in terms of anatomy and operation of the parts of the body concerned is generally a waste of time and often prevents the attaining of the best results. Musical technique and pronunciation furnish good examples. Occasionally explicit attention to the character of the movement seems to be helpful.[1]

Attention should be directed to objective results and the development of individual techniques for acquiring specific skills.

4. **Drill.**—Successful performance requires many repetitions. Barton,[2] who studied the effect of repetition on learning to typewrite, concluded that the larger the number of repetitions, the higher the degree of accuracy. In simple motor processes

[1] Parker, S. C., *Methods of Teaching in High School*, Boston, Ginn, 1920.

[2] Barton, J. W., Comprehensive units in learning typewriting, *Psychol. Rev. Monog.*, 1926, **35**, No. 164.

little drill is required for fixation, while in complex processes many repetitions are necessary. Even though a high degree of efficiency is reached, it is necessary that drill be continued to maintain this level. The amount of drill needed is dependent upon the degree of expertness desired.

5. Length and Distribution of Practice Periods.—The most marked improvement in practice is during periods when both mind and muscle are fresh. It is well known in motor skills that overtraining causes staleness. Periods of practice should be interspersed with intervals of rest and recuperation. These periods of rest and change, unless extended to extreme lengths, permit the learner to approach the task with renewed zest, a new movement or new method of attack which has been devised during the period of rest.

McClatchy[1] shows that in stylus maze learning the practice of regularly inserting rest periods of the same length throughout the period of learning is not the most economical distribution of rest. She found that an interval of 24 hours was the most effective period during the early stages of learning, while longer intervals were most economical for later stages. Murphy[2] experimented upon junior and senior normal-school classes in javelin throwing and divided his subjects into three groups—those who practiced five times per week, those who practiced three times per week and those who practiced once per week. He found that learning periods can be distributed by giving practice on alternate days or even weekly practice without any loss to learning. Snoddy[3] made a detailed analysis of the tracing of a six-pointed star as reflected in a mirror, and found that a recess period during the early stages of learning contributed toward the attainment of accuracy, and that in later stages of learning repetitions without recess contributed toward the attainment of speed.

[1] McClatchy, V. R., The optimal position of a rest period in learning, *J. Exper. Psychol.*, 1925, **8**, 251–277.

[2] Murphy, H. H., Distribution of practice periods in learning, *J. Educ. Psychol.*, 1916, **7**, 150–162.

[3] Snoddy, G. S., An experimental analysis of a case of trial and error learning in human subjects, *Psychol. Rev. Monog.*, 1920, **28**, No. 124.

The length of practice periods varies for different individuals and different skills. When the task requires a variety of movements, longer periods of practice may be provided without undue fatigue. Boredom also plays a part in producing fatigue. A learner who tries to master a certain form in shooting at a basket becomes more readily fatigued than when playing a game involving the same movements. Children profit most by short and frequent periods of practice. The length of practice and the interval between practice periods may profitably be increased with physical and mental maturity.

6. Whole and Part Methods.—Brown[1] performed an experiment in teaching piano music to determine the effectiveness of the whole, part and combination methods. In the first method the score was played from beginning to end without stopping to correct or repeat measures where errors occurred. In the part method the score was divided into units and each unit was practiced an equal number of times. In the combination method the score was played from beginning to end, and all measures where errors occurred were played an equal number of times. She found that in two units out of three the whole method was the most effective. When the most difficult score was assigned to the whole method, it ranked second, while the part method appeared to be least efficient.

Pechstein[2] studied the problem by using a maze which was divided into four parts. One group mastered the maze as a whole, while another mastered its separate parts. He used also a direct repetitive procedure where section 1 was first mastered, then 1 and 2, then 1, 2 and 3, and finally 1, 2, 3 and 4. The reversed repetitive method was used with another group and the progressive part method was assigned one group. In the progressive part method the subjects mastered section 1, then section 2 and combined 1 and 2, then mastered section 3 and combined 1, 2 and 3, and so on until all four were mastered.

[1] Brown, R. W., A comparative study of the whole, part and combination methods of learning piano music, *J. Exper. Psychol.*, 1928, 11, 235–247.

[2] Pechstein, L. A., Alleged elements of waste in learning a motor problem by the part method, *J. Educ. Psychol.*, 1917, 8, 303–310.

Efficiency was determined on the basis of the number of trials and time required and the number of errors made in learning the maze. The results are shown in Table 12.

TABLE 12.—THE EFFECTIVENESS OF THE WHOLE AND PART METHODS IN LEARNING A MAZE
(After Pechstein, 1917)

Method used	No. of subjects	Trials	Time, seconds	Errors
Whole				
Returns allowed.	6	12	641	126
Returns prevented.	6	17	541	81
Part				
Pure part.	6	23	1220	237
Progressive.	6	10	352	57
Direct repetitive.	6	11	618	96
Reversed repetitive.	6	22	1014	226

From his experiments on motor learning Pechstein concluded:

The complex motor problem is probably always best mastered by one of the several "modified part methods." The one universally preferred is the "progressive part."

Distribution of the learning effort is of value for the whole method but not for the part procedure.

Distribution of learning effort is of value for the exploring and eliminative stages of learning, not for the rapid mechanizing stage. Here effort should be massed.

When the conditions of learning call for a massing of learning effort, the whole method becomes increasingly inefficient with increase in problem complexity, the part method increasingly more efficient.[1]

From the results of these and other experiments it is clear that the use of the part, whole, progressive part or combination methods depends upon the length and difficulty of the problem to be mastered. If the task requires few operations for its completion and all are of equal difficulty, the whole method may be proficient. If the task is extremely long and requires

[1] PECHSTEIN, L. A., Whole *vs.* part methods in motor learning, a comparative study, *Psychol. Rev. Monog.*, 1917, **23**, No. 99.

various coordinations, the part method may be effective. If the task contains familiar and unfamiliar combinations of easy and difficult materials, the whole method is a waste of time as the easy parts will be learned sooner than the difficult, but drill must continue over the already perfected parts until the more difficult ones are mastered. In most complicated skills, as in piano playing, the task is only a part of some larger task. The experience of the pupil has brought him a definite way along the path of musical skill. The score with which he experiments is only one part of an organized whole in the development of piano playing. In such cases the part method of learning is obviously used. In general the best method is the combination or progressive part method wherein the learner may spend a longer time on the more difficult and less time on the less difficult parts.

7. **Rhythm.**—Music with a pronounced rhythm tends to increase speed, facilitate coordination and reduce fatigue. Especially is this true of the slow worker. With the rapid worker it has a unifying effect, reducing the speed to the rhythm of the group. Rhythm tends to reduce muscular strain of those muscles not directly concerned with the task. In the effort to coordinate in acquiring muscular skills more energy is developed than is used by muscles directly involved in the task. This energy flows into other channels, causing tension all over the body accompanied by sympathetic movements from other organs. When a child is learning to write it often happens that the head, feet and tongue will keep measure with the hand in forming letters. Rhythm tends to control energy, reducing its generation to cause relaxation in other parts of the body and directing the flow through those muscles employed in the task. There is relaxation of mental strain which reduces fatigue, while the direction of all energy through the proper channels gives added vigor to coordination. The timing of movements in response to rhythm tends to eliminate errors. It is effectively applied to movements in writing, drawing, pronouncing, athletic and track events, calisthenics and folk dancing.

E. Improving Handwriting

The development of scales has provided a relatively new approach to the psychology of handwriting. There has also been developed a number of scoring cards whereby one might diagnose the particular characteristics involved in the subject. In addition to emphasizing legibility and speed, several specific elements including slant, alignment, spacing, and letter formation have been taken into account. The process of improving ability in handwriting may be made clear by reference to several studies where the specific purpose was to affect improvement.

Traxler and Anderson[1] devised an experiment to improve handwriting ability of pupils who were found to be seriously deficient. The materials of instruction were organized around letter formation, slant, alignment and spacing. As a basis for diagnosing ability and furnishing remedial measures the *Freeman Handwriting Manual*, The Ayres Scale for Handwriting, Freeman's Chart for Diagnosing Faults in Handwriting, the Thorndike Scale for Handwriting and several sheets of mimeographed material were used. The handwriting scales were posted on bulletin boards so that they were readily available. As a basis for measuring improvement the Ayres Scale which had been used in the identification of those in need of corrective measures was used. The results show that a training period of two months carried on in connection with the regular English classes resulted in marked improvement. The authors suggest that corrective work may be sponsored with relatively great success by teachers who are not handwriting specialists.

Newland[2] had 24 persons analyze 1,344,905 letters written by 2,381 different individuals who ranged in age from first-grade children to adulthood and found 42,284 specific illegibilities in handwriting. The illegibilities of the letters *a*, *e*, *r* and *t* were

[1] Traxler, Arthur, and H. A. Anderson, Group corrective handwriting in the junior high school—an experiment, *School Rev.*, 1933, 41, 675–684.

[2] Newland, T. E., An analytical study of the development of illegibilities in handwriting from the lower grades to adulthood, *J. Educ. Res.*, 1932–1933, **26**, 249–258.

contributed respectively by 45, 46 and 47 per cent of the elementary, secondary-school and adult groups. Only 14 forms of illegibilities in the elementary and high-school levels and 9 in the adult group contributed 50 per cent of all illegibilities recorded. The results further show that only four types of difficulties in the formation of letters caused over one-half of all the difficulties. The gross frequency of illegibilities appeared to increase with age. The study shows that remedial and corrective work can easily be concentrated upon a few aspects of the total problem. By using charts for diagnosing illegibilities in handwriting it should be possible to affect rapid improvement in the deficiencies found.

F. Tests of Motor Ability

Bovard and Cozens[1] have reported more than 60 tests which relate to measurement of gymnastic, athletic and physical abilities. Some of these tests are designed to predict success in certain types of athletic and gymnastic sports, others to measure achievement, while several have been devised to diagnose and classify students. In general, the aim has been to measure neuromuscular ability with a view to adapting physical activities to individual differences. The earlier tests dealt principally with the measurement of height, weight and girths and other anthropometric measures, while more recent tests have attempted to measure the individual's neuromuscular status as judged by his performance in specific muscular skills. The difficulty encountered in the measurement of ability in athletic and gymnastic tests has been the emphasis upon size and muscular strength, which are relatively unimportant elements in physical skill. Another difficulty encountered in such tests is that they fail to take previous experience into consideration. These difficulties tend to invalidate most tests of neuromuscular skill. Such tests may measure specific skills, but they do not measure neuromuscular or potential ability.

[1] Bovard, J. F., and F. W. Cozens, *Tests and Measurements in Physical Education*, Philadelphia, W. B. Saunders Co., 1930.

Johnson[1] devised a physical-skill test to measure innate neuromuscular skill, which may be used for classification of university students into homogeneous groups. The test has a reliability coefficient of 0.97 and a validity coefficient of 0.67. It consists of a group of exercises requiring various forms of locomotion for a distance of several feet. Each exercise is demonstrated and explained before the students perform the exercise. These tests have proved valuable in classifying university students in physical education.

Many types of peg- and form-board tests have been devised with varying degrees of success. Hayes,[2] using peg boards, studied 1,541 women who were divided into nine classes of shopwork. The relationship between scores on peg boards and efficiency in various types of shopwork as determined by supervisors' ratings was not close, but close enough to indicate significance. The difference in efficiency between those who made high and low scores in the peg board was sufficiently large to justify the use of the peg board as a means of employing workers in one of the Western Electric companies.

Physical and motor tests have proved valuable in measuring innate motor ability and predicting success in various types of performance. It is equally clear that many of them are low in reliability and validity. However, the success already achieved indicates that such tests may be made and practically used in school and industry.

G. Summary

A study of motor skills is important to education because they are used in many of the schools' activities.

Simple motor skills usually employ the large muscles of the body and movements similar to those formed during early infancy and childhood. They are more readily acquired, are less dependent upon mental direction and require less strenuous practice for automatization; the curves of improvement show

[1] Johnson, G. B., Physical skill test for sectioning classes into homogeneous groups, *Res. Quarterly*, 1932, 3, 128–136.

[2] Hayes, E. G., Selecting women for shopwork, *J. Person. Res.*, 1932, 11, 69–85.

rapid initial rises and frequently reach extreme height with few practice periods. Complex skills utilize more of the smaller muscles and require greater delicacy of coordination, more mental direction and concentration, a larger number of concomitant movements and longer periods of practice for development and automatization. The curve of improvement has a slower initial rise and more fluctuations, and maximum height is reached only after much drill and study.

Abilities in skill generally increase with maturity of physical and mental traits. The more complex the skill, the more maturity required for perfection. Boys demonstrate superiority in skills which require strength and size, while in other cases there appears to be little difference between the sexes. When motor tasks require much mental direction, intelligence is a significant factor.

Trial and error is a process of learning to do by doing. The development of motor skills demands that every movement be tested and evaluated on the basis of complete performance. Guidance is a process of limiting the field of trial and error and focalizing attention upon successful processes. Guidance includes putting the subject through the act by manual means, demonstration, explanation, instruction and criticism. Manual guidance is the least effective, while oral explanation and instruction are most valuable. Criticism should be constructive and used only for the purpose of securing better responses. Since success is its own criterion, the objective should be kept in view and form should be stressed only as a means of furthering improvement.

The chief purpose of drill is to fixate responses. The amount of drill required is dependent upon individual ability, type of task and the degree of perfection desired. Frequent short periods of practice are generally more effective for young children. With increase in maturity both the period of practice and the intervals between practices may be lengthened. In general the larger the number of practice periods and the shorter the interval between them, the greater the likelihood of automatization.

The combination or progressive part method is most economical in acquiring skill. The whole method may effectively be used when the movements are simple and the task short. On long and complex tasks the part method is valuable. The progressive part method permits drill where most needed and at the same time affords opportunity for organizing separate movements into a completed pattern.

Scales and scoring cards aid in diagnosing handwriting ability and furnish a means for measuring improvement. Rhythm when adjusted to the various movements of a task facilitates speed and accuracy of performance. Objective tests aid in predicting motor skill ability and in classifying students into homogeneous groups.

CHAPTER VII

IMPROVEMENT IN MENTAL LEARNING

Rote Memorization and Comprehension of Materials

Responses to stimuli in motor learning are by means of overt muscular activities, while in mental learning responses are by means of ideas and thoughts, largely through the medium of language. Words are symbols which represent objects and ideas. Since the major part of the work of the school deals with learning through the medium of these symbols, mental learning is of extraordinary importance. It is in this phase of mental life beyond the attainment of motor habits and skills in which are found the forms of learning of most significance to the school.

A. Rote and Logical Learning

Rote learning involves exact memorization of either meaningless or meaningful material. The pupil may be required to memorize nonsense syllables or a poem with a view to exact reproduction, while in logical learning the individual is expected to study material for the purpose of deriving meanings. He may also be given a problem and the merits of his efforts measured by the correctness of his solution. Rote learning is primarily a mechanical process while logical learning is a rational process.

Rote and logical learning may be more clearly differentiated by the following detailed classification:

1. Rote learning.
   a. Exact memorization of meaningless materials.
   b. Exact memorization of meaningful materials.
2. Logical learning.
   a. Comprehension of materials without exact memorization.
   b. The solution of problems.

Nonsense syllables are learned largely through repetition and there is little basis for the establishment of meaningful associations. In verbatim learning of meaningful material the situation is similar with the qualification that the material is significant and the learner may establish associations which facilitate speed and accuracy. This level is most applicable to memorizing poetry, orations and readings, which demand accurate production.

Logical learning is most frequently used in the schoolroom, although it has been neglected in the laboratory because experimental control cannot easily be developed with meaningful materials. Nonsense syllables furnish excellent material for minimizing past experience and equalizing difficulties for different individuals. One phase of logical learning deals with the type which aims to get meanings from material without *verbatim* reproduction. The pupil is expected to digest materials of assignments so that he may discuss questions and topics during recitations and examinations. Problem-solving procedure may be applied to any school subject and it is only when the pupil is presented with a situation which demands the exercise of originality and creative ability that the highest type of learning may be developed. Because of its distinctiveness problem solving will be separately discussed in the succeeding chapter.

Rote learning as previously noted is verbatim learning of either meaningless or meaningful material. If meaningful material is used, meanings are incidental rather than purposeful. When meaningless material is used, learning is always rote, but with meaningful material it may be either rote or logical. Therefore, an attempt will be made to determine whether laws and principles developed on the basis of meaningless material apply with equal force to the learning of material with meaning.

B. Curves of Improvement

The curve of improvement which indicates increased efficiency with continued practice makes it possible to determine the amount and quality of learning in the experimental laboratory or school. When the results of learning are graphically repre-

sented, the curve indicates whether or not improvement has been effected by training. The amount of learning at successive stages in the training period and the limits of learning progress may be determined by interpreting the curve. Improvement curves are ascending or descending according to the method of plotting. If correct responses are plotted on the ordinate, the curve rises with successive periods of practice. If errors or time records are plotted on the ordinate, the curve descends. The essential characteristics are the same. Curves indicate trends in rate and accuracy of performance.

Curves have been developed on the basis of varying materials with differing groups and time limits. One curve may be constructed on the basis of nonsense syllables with a ten-minute practice period, another may involve two weeks' practice with college students in learning poetry, while others may be based upon performance of elementary-school children in addition of numbers. The chief difficulty in establishing curves which adequately represent the true condition has been lack of uniformity and confirmation of investigations. Because of this confused condition, the results of several typical investigations, including both meaningless and meaningful materials, have been tabulated. Curves have been developed which depict the results of composite treatment of a large mass of diversified data. Such compilation should aid the student in forming a general idea of the curves of improvement and their characteristics.

1. Types of Curves.—In the acquisition of skill the convex type of curve is common, while in mental learning the concave type is often found. Curves of mental learning have also been classified as convex-concave and as variations of these forms. Meumann[1] claims that there are at least three types of curves for mental work. One reaches maximum efficiency at the beginning and decreases with many fluctuations; another obtains maximum efficiency only after an interval of great length; while a third shows slower adaptations and high resistance to fatigue. Ruch[2] shows that there is no one kind of curve which is inde-

[1] Garth, T. R., Work curves, *J. Educ. Psychol.*, 1919, 10, 277–284.

[2] Ruch, G. M., The influence of the factor of intelligence on the form of the learning curve, *Psychol. Rev. Monog.*, 1925, 34, No. 160.

TABLE 13.—SOME TYPICAL INVESTIGATIONS DEALING WITH THE LEARNING OF MEANINGLESS MATERIAL

		No. and age of subjects	Learning activity	Criteria of learning	Length of practice period
1. Lyon (1914)	a.	14 adults	Nonsense syllables	Time taken to learn	14½ months
	b.	14 adults	Nonsense syllables	Time taken to learn	14½ months
	c.	14 adults	Nonsense syllables	Time taken to learn	14½ months
2. Robinson and Heron (1922)	a.	10 adults	6 nonsense syllables	Learning time and recall	2 sec. exposure of each syllable
	b.	10 adults	9 nonsense syllables	Learning time and recall	2 sec. exposure of each syllable
	c.	10 adults	12 nonsense syllables	Learning time and recall	2 sec. exposure of each syllable
	d.	10 adults	15 nonsense syllables	Learning time and recall	2 sec. exposure of each syllable
	e.	10 adults	18 nonsense syllables	Learning time and recall	2 sec. exposure of each syllable
3. Robinson and Darrow (1924)	a.	80 adults	4 digits	Learning time and recall	2 to 15 min.
	b.	80 adults	6 digits	Learning time	2 to 15 min.
	c.	80 adults	8 digits	Learning time	2 to 15 min.
	d.	80 adults	10 digits	Learning time and recall	2 to 15 min.
	e.	80 adults	6 nonsense syllables	Learning time and recall	20 min.
	f.	80 adults	9 nonsense syllables	Learning time and recall	20 min.
	g.	80 adults	12 nonsense syllables	Learning time and recall	20 min.
	h.	80 adults	15 nonsense syllables	Learning time and recall	20 min.
	i.	80 adults	18 nonsense syllables	Learning time and recall	20 min.

pendent of the function being investigated and of the differences in intelligence of pupils undergoing practice.

The question has led to theories of single and multiple types. In testing these two theories there has been an attempt to determine results when the same individual practices the same

TABLE 14.—SOME TYPICAL INVESTIGATIONS DEALING WITH THE LEARNING OF MEANINGFUL MATERIAL

	No. and age of subjects	Learning activity	Criteria of learning	Length of practice period
1. Averill (1924)	1 subject	Digit symbols	No. of digit symbols written	1 to 25 practices; 1 min. each practice
2. Brooks (1924)	24 college students	Cancellation, mental multiplication and inverted writing	No. of correct figures minus 1/10 no. of incorrect figures	1 to 14 periods of practice
3. Dashiell (1920)	10 college students	Addition	No. of correct columns per trial	1 to 14 trials
4. Lyon (1914)				
a.	1 subject	Poetry	Stanzas learned	Period of 312 min.
b.	1 subject	Poetry	Stanzas learned	Period of 385 min.
c.	1 subject	Poetry	Stanzas learned	Period of 33 days
d.	1 subject	Words	No. of words learned	Period of 202 min.
e.	1 subject	Words	No. of words learned	Period of 186 min.
f.	1 subject	Prose	No. of words learned	Period of 73 days
g.	1 subject	Prose	No. of words learned	Period of 5475 min.
5. Peterson (1918)	10 adult subjects	Memory-reason, type test	Average no. of errors	15 trials
6. Stumpf (1928)	2 high-school students	Civics	No. of correct items per day	20 periods of 1 hr.

function for extended lengths of time. Garth[1] shows that, when all factors are considered and when the averages of many individuals are compared with one curve, there is greater similarity than difference. The same characteristics are noted in all curves, but they occur at different stages. Some individuals do well at the beginning and later decrease in

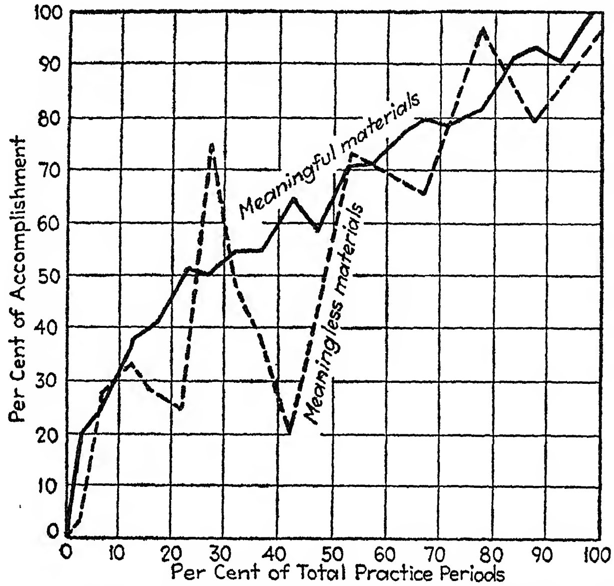


FIG. 7.—The broken line represents a composite of 17 studies dealing with meaningless material, while the full line represents a composite of 23 studies dealing with meaningful material. The curves show the relationship between accomplishment and continued practice as expressed in terms of percentages. For example, during the first 5 per cent of the total number of practice periods there is a certain per cent of the total accomplishment for the study. The highest degree of accomplishment is represented by 100 per cent and the total number of practice periods (irrespective of number) is also represented by 100 per cent.

efficiency, while others do poorly at the beginning and increase in efficiency as practice continues. Others vary between these extremes.

A partial answer to the controversy concerning types of curves may be obtained from an analysis based upon studies in Tables 13 and 14, and others. The curves include both meaningless

[1] GARTH, *op. cit.*

and meaningful materials and are made comparable by percentages of increase in efficiency with increased practice. These studies when treated separately show marked variations corresponding to different types of materials, measuring instruments and individual differences of subjects. However, when results of several investigations are treated compositely and are made comparable according to the percentage method, it is clear that the curves assume the same general form. The important consideration is to know theoretical expectancy and to interpret each curve according to its own conditioning factors.

A study of the curves in Fig. 7 shows that for meaningless materials the rise is very erratic while with meaningful materials it is fairly constant. This condition may be explained chiefly by the associations in meaningful materials which enable the learner to work at a more stable rate. When meaningless materials are used, the curve indicates that there are numerous pronounced fluctuations which begin early in the learning period, while with meaningful materials fluctuations appear later and are less frequent. There are also few declines and slight loss. These differences may be attributed to the presence of associations in meaningful materials. In meaningless materials there is likely to be more monotony and decline, due to the mechanical nature of learning which demands constant repetition to maintain and improve achievement.

2. Characteristics of Curves.—Improvement is not manifested as a steady rise. There are sudden rises and declines. There are also plateaus or periods of no apparent improvement. These characteristics vary widely in their manifestations, and are terms which can be used only in the most relative sense. Initial rises may be pronounced or barely perceptible, fluctuations may be marked or slight, plateaus may be long or short. There are also occasions when a sudden rise following a period of normal progress indicates that some factor commonly termed insight has produced almost immediate solution of the problem.

a. Initial Rise.—The typical curve indicates a relatively rapid rise in the initial stages of learning followed by a gradual

increase in the later stages. There have been numerous explanations of this initial rise. It is held that the individual shows greater improvement during initial performance because the task is novel, because at this stage he is vigorous and free from fatigue and because tasks which are relatively simple during the initial stages of learning may become increasingly more complex as practice continues. There is the further explanation that more progress is possible at the beginning than later because the nearer the individual approaches the end of his task, the less the possibility of improvement. Some curves, because of the difficulty of mastering the materials during the initial stages of learning or because of the lack of an impelling incentive, show very gradual initial rise followed by marked improvement.

A few studies suggest that the initial rise varies with the complexity of the process and in some types of material is not present. Thorndike, contrary to what most investigators believe, is skeptical of the existence of such a spurt.[1] Chapman,[2] who tested college students, found a pronounced spurt in adding number columns. His data indicate that he has avoided the limitations of many experiments by measuring continuous work over a long period. Phillips[3] compared the amount of work accomplished during the first minute with that of each succeeding minute of a 10-minute practice period. He found that from 6 to 12 per cent more work was accomplished in the first minute of a 10-minute test in the fundamentals of arithmetic than in the average of the later minutes. The work of the first minute of practice was more stable and errors were less frequent. Nolan and Chapman[4] found that 28.8 per cent more work is done during the first interval than during the average of the last 20 intervals.

[1] THORNDIKE, E. L., The curve of work, *Psychol. Rev.*, 1912, **19**, 165–194.

[2] CHAPMAN, J. C., A study of the initial spurt in the case of addition, *J. Educ. Psychol.*, 1915, **6**, 419–426.

[3] PHILLIPS, F. M., A comparison of the work done in successive minutes of a ten minute practice period in the fundamentals of arithmetic, *J. Educ. Psychol.*, 1916, **7**, 271–277.

[4] NOLAN, W. J., and J. C. CHAPMAN, Initial spurt in a simple mental function, *Amer. J. Psychol.*, 1916, **27**, 256–260.

Initial spurts occur in most functions and may be attributed to several factors including the ease with which some materials may be mastered during the initial stages, incentives, interest in a new undertaking and types of material.

b. Fluctuations.—The curve of improvement fluctuates with successive periods of practice. These fluctuations may vary from those which are barely perceptible to those which appear as tall steeples, and they may be due to various factors in the learning process. One of the most noticeable factors is the presence of specific difficulties in the learning situation which cause retardation and thus a decline in the improvement curve, followed by a sudden rise to a point above the previous level. There is the warming-up effect which has been defined by Thorndike as "that part of an increase in efficiency during the first 20 minutes (or some other assigned early portion) of a work period which is abolished by a moderate rest of say 60 minutes."[1] There are also end spurts which are often observed in individuals as they approach the end of their work period when there is a definite time limit. There are spurts after fatigue, as when the individual resumes his work after a period of rest, and spurts after disturbance, as when an individual has been interrupted and feels that he is compelled to make up for any loss of time.

Other factors include physical and mental condition, the control of emotions, effort and attention and the relation of interest to the problem. Such physical conditions as headaches, loss of sleep and sensory defects influence steadiness of progress. Some individuals because of nervousness and susceptibility to excitement find it difficult to work under pressure and become erratic. Some attempt to work too rapidly and commit many errors. Others find it difficult to hold their attention to any task for a long time or to continue practice upon uninteresting or monotonous materials.

c. Plateaus.—The term *plateau* is used by some investigators to indicate all suspended progress, whether of daily or of longer duration. The term plateau may be defined as a comparatively

[1] THORNDIKE, *op. cit.*

long period of no apparent progress. This definition makes it possible to differentiate between fluctuations and periods of no perceptible progress.

Book[1] believes that plateaus are periods of genuine arrest during which there is no further development of elemental habits in preparation for their use in higher-order habits. They are due according to him to lapses of attention, to relaxation of interest and effort, and are attended by increased effort as soon as recognized. Pyle[2] believes that they are periods of no progress and that they are due to flagging interest. He believes that plateaus are valuable in habit formation because they lead to renewed interest and effort in resuming work and to a weakening of inhibitions which interfere with the formation of habits.

As a result of his experiments in both motor and mental learning, Swift[3] concludes that lower- and higher-order habits are continuously and simultaneously present and being automatized, and that plateaus form the most conspicuous part of the improvement curve. He believes that visibly they are resting places, but that actually they are periods when real progress is being made—periods of automatization and assimilation, the length and number of which are affected by such factors as physical condition, interest and monotony. The fact that he was able to prevent many of the longer types of plateaus tends to confirm this point of view. He says:

> The cause of these stationary periods of invisible progress which are called plateaus is need for time for assimilation and automatization. They are times when marks tell only a part of the truth. Though there is no visible advance, real progress nevertheless is going on in organizing the chaotic mass of bits of disconnected information which the learner has acquired so that they may be used quickly and more accurately.

He thinks that although they are essential to the learning process they are unnecessarily increased in number and depress-

[1] BOOK, W. F., *The Psychology of Skill*, New York, Gregg, 1925.

[2] PYLE, W. H., *The Psychology of Learning*, Baltimore, Warwick and York, 1921.

[3] SWIFT, E. J., *Learning and Doing*, Indianapolis, Bobbs-Merrill, 1914.

ingly prolonged by shakiness of foundation work which produces attitudes of failure. Ruger[1] also interprets plateaus as periods of organization and association of elements into a unitary whole.

Swift, in an experiment upon himself in learning the Russian language, found several distinct plateaus, one lasting from about the eighteenth to the forty-eighth day of study, in addition to many daily fluctuations. He also experimented with a class in psychology and found a distinct plateau continuing from the twenty-fifth to the sixty-fifth day. Swift concluded that plateaus (longer ones) inevitably occur in studying subjects in which earlier work is essential (grammar, arithmetic, foreign language) as a basis for later understanding. He believes that plateaus (long or short) are due to subjective rather than objective factors. Although a plateau may occur mentally, if it is immediately overcome it may not be revealed by objective measurement.

From these and other data plateaus appear to be due to: (1) organization, assimilation and automatization periods; (2) many objective and subjective factors such as immediate environment, physical condition and lapse of attention, interest and effort; (3) mental attitude, or direction of emphasis as to speed or quality; (4) psychological, mechanical and thought-process limits. Plateaus may also be due to poor organization of textbook subject matter or to defective presentation by the teacher as well as to partial learning on the part of the pupil.

Long plateaus are in general not universal for all individuals and types of materials. Short plateaus, however, appear to be common to all individuals and types of materials. Critical stages are universal but under favorable conditions may not be revealed by objective tests. Some plateaus are periods of genuine progress—of organization, assimilation and automatization of simple habits into higher order habits. Others are periods of no perceptible or concealed progress. Whether long or short plateaus occur depends upon the task under consideration, the proper use of incentives and motivating devices and

[1] Ruger, H. A., The psychology of efficiency, *Arch. Psychol.*, 1910, 2, No. 15.

the organization and presentation of subject matter, as well as the ability of the pupil to maintain perseverance and industry in the face of difficulties.

3. **Insight.**—Another characteristic of the improvement curve is a marked rise to a distinctly higher level of acquisition. The cause of this sudden change is attributed to insight. Insight implies that the solution of the problem or some part of it has suddenly appeared and the problem is solved on the basis of previously formed habits. The insight factor may occur early or late in the training period. When it appears after training has been in progress for some time, it is usually attributed to the result of integration of previous attempts at solution. The learner is believed to sense the solution without further use of the trial-and-error method.

Several types of insight may be noted. There is that type which apparently manifests itself as accidental discovery in the course of random effort. There is also the type which occurs as the result of integrating a number of trials. There is a third type which is the result of previous experience in similar situations. The first may not appropriately be termed insight as the term is generally understood because it is the result of chance. The second is more accurately termed insight because it involves "seeing through" the problem in the light of previous trials. In the degree to which this is true it is closely related to the third with the qualification that the previous experience is more immediate and does not contain the exact solution. The second may be considered typical of that type of insight which produces a new solution so far as the learner is concerned. The third type of insight is typical of intelligent responses to a situation which has meaning for the learner. Most students have had the experience of laboring for a long time on an intellectual problem, amassing a variety of points of view and reaching a period of almost fatal dejection, when with apparent suddenness the whole situation was clarified and the solution indicated. Integration has produced comprehension of the problem.

C. Individual Differences in Improvement

Investigators have found varying results from a study of the influence of practice on individual differences in learning. From a study of 24 sets of experiments conducted by various experimenters, Kincaid[1] concluded that there is in general a significant degree of correlation between ability at the beginning and at the end of comparatively short periods of practice. On the basis of her analysis she concluded that one may with considerable assurance predict later relative positions from initial scores. She also concluded that identical and continuous training, instead of making pupils less alike, tends to reduce individual differences. Her study further showed that on the average there was a negative correlation between initial ability and percentage of gain in 22 out of 24 studies. These findings, in view of conflicting evidence from other investigators, reopen the whole question of the relative influences of heredity and environment.

1. Intelligence.—It was formerly believed that those who learned rapidly forgot quickly and that the pupil who learned slowly retained more of that which he learned than did the relatively rapid learner. Such assumptions are usually false. It is possible to determine important differences between bright and dull children by studying periods of acceleration[2] and retardation. The improvement curves of bright children differ both in nature and amount from those of the dull. Successful learning is characterized, not only by the ease of acquirement, but also by the ability to avoid errors. The dull child requires more repetitions and commits a larger number of errors.

In determining improvement of bright and dull pupils, we may study individual differences of typical children, or of children who represent extremes in intelligence. Fildes[3] used

[1] Kincaid, Margaret, A study of individual differences in learning, *Psychol. Rev.*, 1925, 32, 34–53.

[2] Baldwin, B. T., The learning of delinquent adolescent girls as shown by substitution tests, *J. Educ. Psychol.*, 1913, 4, 317–332.

[3] Fildes, Lucy J., Some memory experiments with high grade defectives, *Brit. J. Psychol.*, 1923, 14, 39–56.

the second method in studying the improvement of high-grade defectives and normal children of similar ages who were compared on the basis of rate and accuracy. Eight forms were used and associated arbitrarily with eight nonsense words as names. Some of her results are given in Tables 15 and 16.

TABLE 15.—SHOWING THE NUMBER OF REPETITIONS REQUIRED FOR LEARNING (After Fildes, 1923)

	30 M. D. boys	25 M. D. boys	25 normals
Average age....	12 years 3 months	13 years 0 months	11 years 1 month
Average number of repetitions required for learning......	13.3	11.4	5.64

Table 15 shows that the defectives require about twice as many repetitions for successful learning. Table 16 shows a comparison of defective and normal children in the ability to avoid errors.

TABLE 16.—SHOWING THE NUMBER OF TIMES EACH SYLLABLE OR FORM IS WRONGLY GIVEN BY DEFECTIVES AND NORMAL CHILDREN (After Fildes, 1923)

Forms wrongly given		Names wrongly given	
Defectives	Normals	Defectives	Normals
125	50	110	28
24	30	94	45
32	36	138	30
32	25	91	27
233	39	104	48
268	61	171	57
118	40	68	33
71	26	87	29

Fildes's results indicate that defective children have: (1) "less power than normals for forming associations except such as are very obvious or are forced upon them from outside; (2) a tendency to be confused rather than helped by chance associations

that arise; (3) less power of criticizing their results; (4) less ability to work under new conditions; and (5) a tendency to automatism."

Even when persistency has been equalized,[1] the bright pupil not only learns more quickly, but retains a higher percentage of what he learns. The bright pupil also uses more efficient methods of study and makes better adaptations of attention. Tasks should be made so definite and comprehensive that the fast learner will feel the need of working up to his capacity, and will not be satisfied in doing mediocre work along with his less fortunate classmates.

2. **Age.**—Childhood has been believed to be the best period both for learning and for retaining. The arguments usually proposed for this point of view are that the child is plastic, that his mind is relatively unoccupied and hence is adaptable and subservient to the demands of parents and teachers. This popular notion probably had its origin in the theory that mental traits develop at different stages in the individual's growth. Experimental psychology tends to show, however, that mental functions develop gradually and concomitantly. Memory, reasoning and other processes manifest themselves early in the life of the individual and there is a continuous development through adolescence. Both memory and reasoning are possessed by very young children. The difference between a child of five and one of fourteen years of age is the degree to which these processes have developed. Mental functions grow in strength with age within certain limits which are not conclusively established, although most authorities believe that the limits of mental growth are not reached before sixteen or eighteen years.

Increase in age indicates a corresponding increase in learning ability within age limits. When the same tests are applied to children of various ages up to sixteen or eighteen years, they show that older children learn more quickly and retain a greater amount than younger children. The child cannot learn as easily

[1] Chapman, J. C., Persistence, success and speed in a mental task, *Ped. Sem.*, 1924, 31, 226–284.

as the adult because he is unable to concentrate his attention for a long time; he is lacking in experience and associations, requires more repetitions and his improvement through practice is less than that of older persons. The child's incentive to learn is less impelling and is of a different nature than that of the adult. Since the child has limited experience, his method of learning is likely to be uneconomical.

3. Sex.—Sex differences have been investigated in most studies dealing with general intelligence, achievement in school subjects and improvement in learning. General intelligence tests usually show that boys and girls are approximately equal, with the possible exception of differences during the period of puberty when girls are superior; this is usually explained by variations in the rate of physical growth. There are some tests weighted in favor of boys; likewise there are certain parts of tests which are weighted in favor of girls. General intelligence tests do not usually indicate significant sex differences. In school subjects the differences between the sexes are more marked, but they may be attributed to the type of subject matter being measured. Some investigations show that girls excel in such subjects as language and literature, while in natural and social sciences the boys are superior.

Although the findings of a majority of experiments in mental learning have tended to favor girls,[1] they depend upon the kind of material measured. If one kind of material is used, one may say that girls are better learners; if another kind of material, that boys are more efficient; with some types of material the sexes are approximately equal. Consequently differences between sexes in learning capacity may be attributed to types of material and training.

D. Economy in Mental Learning

1. Incidental versus Guided Learning.—One of the first observations that may be made of learning in the psychological

[1] Pyle, W. H., The relation of sex differences to kind of material used, *J. Educ. Psychol.*, 1925, 16, 261–264.

Also, Pyle, W. H., Sex differences and sex variability in learning capacity, *School & Soc.*, 1924, 19, 352.

laboratory is that improvement is assured. In the laboratory there are specific practice upon functions to be improved, definite time limits, control of irrelevant influences, constant awareness of success and error and maximum motivation. The learner is guided and supervised in the learning process and is urged to exert maximum effort. Practice in the school is likely to be general, with little attempt to measure progress objectively, and motivation may be at a minimum. Learning outside of the school is still more incidental and uneconomical. The difference between the effectiveness of learning in the psychological laboratory and the school may be attributed to specific and purposeful guidance, which is everywhere evident in the laboratory but may be absent in the school.

The school, in order to increase efficiency, should establish definite objectives of achievement in subjects and courses, determine abilities and skills to be developed, measure progress at definite periods and supply incentives for the creation of favorable attitudes toward work. Pupils profit most by training when courses are organized with specific goals to be attained and abilities to be developed and when there are definite time limits for the performance of tasks.

2. The Length and Distribution of Practice Periods.—The numerous studies on this subject owe their inception to Ebbinghaus, who found that it was more economical to distribute practice periods in learning nonsense syllables than to concentrate them in shorter periods. Recent investigators have experimented with both meaningless and meaningful materials.

a. Meaningless Materials.—Lyon,[1] using himself as subject, tested the effectiveness of repetitions made once a day and those continuously made. In this study he learned varying amounts of nonsense syllables, digits, prose and poetry. The experiment involved the time taken for complete learning by the two methods. The total time taken when learning poetry and prose by the "once per day" method was almost as long as that taken by the "continuous" method. In learning nonsense

[1] Lyon, D. O., The relation of length of material to time taken for learning; the optimum distribution of time, *J. Educ. Psychol.*, 1914, **5**, 1–9, 85–91, 155–163.

syllables and digits, however, there was much saving in time by the "once per day" method. The time taken to learn by the "once per day" method varied according to the length of material. In nonsense syllables and digits, the shorter lists showed a decided advantage in time by the "once per day" method; for the larger units of work distributed practice was notably economical. Lyon believes that the chief advantage of the "once per day" method is that material so learned is retained for a much longer period.

Perkins[1] also tested the effectiveness of distributed and concentrated study in learning nonsense syllables. Sixteen repetitions of lists of nonsense syllables were divided into periods consisting of one, two, three, four and eight readings of the lists with one-, two-, three- and four-day intervals for each length period. She wished to determine if there were a limit to the degree of distribution that might be advantageous and to determine, in cases where there was more than one repetition made on a single day, if learning were easier when more than one day was allowed to intervene between groups of readings. She found that success is better when one reading is made at each sitting, and that in general the fewer the number of repetitions made at a sitting, the greater the degree of success. The most favorable interval between sittings was between two and three days for cases where there were one or two repetitions at a sitting; for cases in which four to eight repetitions were made at a sitting, the longer interval of three or four days had more value.

b. Meaningful Materials.—Starch[2] made an investigation in which the learning situation consisted in having students transcribe prose by writing appropriate numbers into squares opposite each line of print. Forty-two college students, divided into four groups, took part in the experiment. To make a comparative analysis of distributed and concentrated practice, the groups were studied in the following manner:

[1] PERKINS, NELLIE L., The value of distributed rote learning, *Brit. J. Psychol.*, 1914, 7, 253–261.

[2] STARCH, DANIEL, Periods of work in learning, *J. Educ. Psychol.*, 1912, 3, 209–213.

Group	No. of cases	Length of practice periods, minutes	Time interval between periods	How long practice continued, days
I	12	10	Twice a day	6
II	14	20	Once a day	6
III	9	40	Every other day	6
IV	7	120	One continuous sitting	

His results clearly indicate that the shorter and the more frequent the practice periods, the greater the amount of

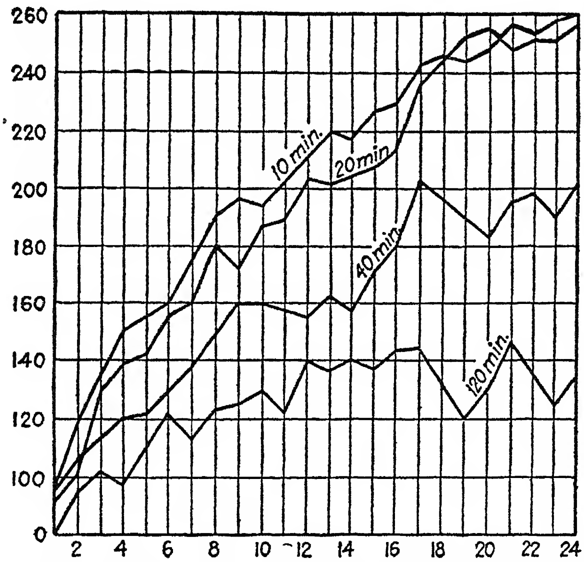


FIG. 8.—The numbers on the base line represent the successive 5-minute periods while the vertical numbers give the number of letters transcribed during each 5-minute period. (*After Starch*, 1912.)

improvement. The 10-minute period is definitely the most efficient, while the others follow in descending order of importance. However, it cannot be said that, because the 10-minute period is most efficient, still shorter periods of practice would show corresponding advantages. There is a limit to the economy in shortening and distributing periods of work. As Starch suggests, there is an indication from the results that

were the periods shorter their advantage would be overbalanced by the time it takes to "warm up" at the beginning of each period.

These results are confirmed by Reed.[1] Reed tested the effectiveness of distributed and concentrated learning in addition of two-place numbers in which there were no zeros. To compare the effectiveness of the two methods, four groups were studied as follows:

Group	No. of cases	Length of practice period, minutes	Time interval between periods	How long continued
I	60	60	Continuously	
II	50	20	Once a day	3 days
III	51	10	Once a day	6 days
IV	42	10	Twice a week	3 weeks

The results of Reed's study, which are presented in Table 17, indicate that the 20-minute period once a day for three days proves most efficient of all both for absolute and for relative gains.

TABLE 17.—THE EFFECT OF DISTRIBUTION OF TIME ON LEARNING TO ADD TWO-PLACE NUMBERS
(After Reed, 1924)

Group	Attempts		Gains		Rights		Gains	
	First 10 min.	Last 10 min.	Absolute	Relative	First	Last	Absolute	Relative
I—60 min....	42.9	47	4.1	10.9	40.	44.7	4.7	12.2
II—20 min....	43.7	58.4	14.7	35.9	40.7	56.4	15.7	43.4
III—10 min....	47.2	62.7	15.3	33.1	46.3	59.8	14.9	33.6
IV—10 min....	45.1	59.7	14.6	28.6	42.3	57.2	14.8	35.1

[1] REED, H. B., Distributed practice in addition, *J. Educ. Psychol.*, 1924, **15**, 248–249.

Other investigators using meaningful materials include Kirby,[1] who approached the problem of the most favorable length of period when there was an interval of one day between addition and division. His results show that two minutes per day are more efficient than the longer periods. Hahn and Thorndike[2] have studied the same problem in the case of addition. Their findings show that a 22½-minute period is better than an 11½-minute period for the seventh-grade pupils; the 10-minute period is about equally superior to a 5-minute period for the fourth grade; however, in the sixth grade, 20 minutes are only slightly superior to 10 minutes, and 7½ and 15 minutes are about equal in efficiency for children in the fifth grade.

In general, distributing work over a long period is more efficient than concentrating it in short periods. Several theories have been suggested to explain why distributed work is more economical than that which is concentrated. Lashley[3] believes that during long periods of practice the learner is likely to get into a rut, and that intervals of rest permit him to return to the problem with a new mental set to attack it in a different way. Spight[4] interprets the greater effectiveness of distributed learning in terms of a physiological process because individuals make more improvement when their work has been interspersed by sleep. Others attribute the superiority of distributed work to the greater number of associations which is formed. When the learner spreads his efforts in a particular assignment or course over a period of time, there is greater opportunity to evaluate and assimilate materials. There is also opportunity for frequent recall, which keeps materials alive. Such distribution not only affects ease and rapidity of learning, but makes for greater retention.

[1] Kirby, T. J., Practice in the case of school children, *Teach. Coll. Contrib. Educ.*, 1913, No. 58.

[2] Hahn, H. H., and E. L. Thorndike, Some results of practice in addition under school conditions, *J. Educ. Psychol.*, 1914, **5**, 65–84.

[3] Lashley, K. S., A causal factor in the relation of distribution and practice to the rate of learning, *J. Animal Behav.*, 1917, **7**, 139–142.

[4] Spight, Julia B., Day and night intervals and the distribution of practice, *J. Exper. Psychol.*, 1928, **11**, 397–398.

Unfortunately the greater part of experimental work on this problem has been performed with adults rather than with children of various ages and degrees of maturity. Children require shorter practice periods than do adults. They are more susceptible to fatigue, have less perseverance and shorter spans of attention. The relative effectiveness of distributed and concentrated learning depends, among other things, upon length of material and its nature and difficulty. When materials are meaningful, longer practice periods, as well as wider intervals between practice, may be used.

3. The Length of Material and Effort Required to Learn.—The problem of length of material and effort required to learn is of immediate practical interest to teaching because the assignment is not usually made with a view to the relation between its length and the effort expended by pupils.

Ebbinghaus formulated a law of relationship between length of material and the number of repetitions necessary to learn it to the point of one errorless reproduction. He found that while 7 syllables could be recalled with one presentation, 12 syllables required 16.6 repetitions; 16 syllables, 30 repetitions; 24 syllables, 44 repetitions; and 36 syllables, 55 repetitions. In brief, it was shown that as the number of syllables in a series increased, the number of repetitions required for learning increased more rapidly than in proportion to the increase in the number of syllables. There have been several theories to explain Ebbinghaus's findings. It has been held that the greater the number in a series, the less attention is paid to each member. With a long series, the process of forgetting has been in operation longer than in the short series, because it takes longer to read the greater number of repetitions needed. The longer series tends to cause more fatigue and consequently individual syllables receive less effort.

In direct opposition to the law of Ebbinghaus is that of Meumann, who believed that when the number of syllables in a series is increased there is a disproportionately small increase in the number of repetitions required.

Since the theories of Ebbinghaus and Meumann were formulated, several studies have been made for the purpose of

testing them. Lyon[1] experimented on himself with nonsense syllables, digits, poetry and prose and provided data on the relationship between time taken for learning and length of material. In Table 18, data for digits and prose only are given from his results.

Henmon,[2] using nonsense and meaningful materials, found relative economy in using larger amounts. The economy

TABLE 18.—THE RELATION BETWEEN THE AMOUNT LEARNED AND TIME TAKEN TO LEARN

(After Lyon, 1914)

Digits

Number of digits	8	12	16	24	32	48	72	104	200	400
Time taken in minutes learned by continuous method	½	¼	2	5	10	18	34	56	154	
Time taken (1 repetition per day)	½	½	⅕	4	7	9	21	35	85	233

Prose

Number of words	25	50	80	100	175	300	600	800	1000	1200
Time taken in minutes continuous method	¼	3	5	9	21	30	71	133	168	202
Time taken (1 repetition per day)	⅛	2¼	4½	9	22	36	84	136	165	186

in relearning after 24 hours was greater with larger amounts, and was relatively greater with meaningful materials than with nonsense syllables. Robinson and Heron[3] have shown that the number of repetitions required for complete learning increases rapidly with early increases in length of material and more slowly with later ones. Their results show not only a continuous increase in repetitions with increasing length, but also an increase in repetitions per syllable.

These writers have also shown that the method of considering the relationship between the number of repetitions required to

[1] LYON, *op. cit.*

[2] HENMON, V. A. C., Relation between learning and retention and the amount to be learned, *J. Exper. Psychol.*, 1917, 2, 476.

[3] ROBINSON, E. S., and W. T. HERON, Results of variation in length of memorized material, *J. Exper. Psychol.*, 1922, 5, 428–448.

learn and length of material is not very satisfactory for determining the relationship between length and difficulty. They point out that one repetition is a unit in which the magnitude varies directly with the length of the material. When the effort required to learn is measured in terms of constant amounts, the relationship between length and difficulty increases at a rapid rate. These findings are confirmed in a further study by Robinson and Darrow,[1] who used both meaningless and meaningful materials and found that the amount of time required for learning increases at a growing rate as the number of lists becomes larger. The trend of their results indicates that as material becomes longer, it becomes relatively more difficult. They also show that there is a general tendency for the rate of forgetting to vary inversely according to the length of the number lists.

It is probable that Ebbinghaus's law holds to a certain point in the increase of learning material, while Meumann's law holds for learning material beyond that point.[2] As material is lengthened, there is, within limits, a corresponding increase in time and effort required to learn. However, from the standpoint of economy of learning, materials of considerable length are far more economical of time and energy expended by the pupil. Lengthy materials afford opportunity to divide work into meaningful units and to form a large number of associations which are impossible with short materials. There is greater opportunity to organize knowledge of meaningful material and learn it more as a whole. With large units there is the further advantage of extending study over a wider period, thus utilizing the principle of distributed work. The length of the assignment will necessarily vary with familiarity and type of material. When material is meaningful and the pupils are familiar with the work at hand, the assignment may be extended, but when the material is new or difficult, short assignments are more satis-

[1] Robinson, E. S., and C. D. Darrow, The effect of length of list upon memory for numbers, *Amer. J. Psychol.*, 1924, **35**, 235–243.

[2] Skaggs, E. B., The relation of length of materials and number of repetitions needed to learn, *Gen. Psychol.*, 1929, **2**, 150–152.

factory. As a rule it is better to assign a complete topic than part of a topic, as connected wholes are more economical than disconnected parts.

4. **Whole and Part Methods.**—The principle of whole and part methods has been studied primarily in connection with memorizing poetry and nonsense syllables, but it may also be applied to prose. It is possible in memorizing a poem to go over the material as a unit many times or to memorize separately each part. The pupil in learning an assignment in history may study a topic or a unit as a whole or he may study separately the various subsidiary topics. Some of the arguments advanced in favor of the two methods include the following:

1. Advantages of whole method.
   a. Retention is better.
   b. Fewer repetitions are required.
   c. A larger number of associations is formed.
   d. Time and effort are saved.
2. Advantages of part method.
   a. Pupils prefer the part method.
   b. It effects relatively rapid learning.
   c. It adjusts itself more adequately to the child's span of attention.
   d. It adjusts itself more adequately to long and difficult materials.

Although some recent investigators[1] have tended to show that the part method is superior, most of them have held that the whole method is more efficient. Learning by the whole method insures the formation of pertinent associations and the comprehension of isolated parts in a way that cannot be accomplished when material is learned in parts. The mediating method, which is a combination of the part and whole methods, includes the advantages of both, and at the same time reduces their respective disadvantages. Myerhart[2] has summarized the relative advantages of the part, whole and mediating methods in the following statements:

[1] Reed, H. B., Part and whole methods of learning, *J. Educ. Psychol.*, 1924, **15**, 107–115.

[2] Myerhart, M. W., Economical learning, *Ped. Sem.*, 1906, 13, 145–184.

1. Each of the old methods has its characteristic strong and weak points:
   a. The weakness of the part method consists in the formation of irrelevant associations; its advantages in the setting in of attention with full vigor and energy at the beginning of each part.
   b. The weakness of the whole method consists in the relaxation of attention so that the middle part of the material is not so thoroughly learned as at the beginning and the end. Its advantage is to be sought for in the formation of associations in that direction only in which they shall be effective in reproduction; again it prevents mere motor recitation which, for the process of learning, remains relatively or entirely ineffective.
2. The mediating method combines the advantages of the whole and part methods and avoids their respective disadvantages.
3. The question of which method of learning is more economical can be answered from two points of view. A method may be advantageous because it leads quicker to a first errorless recitation, or because it effects more accurate and permanent retention.
4. The part method, as far as rapid learning is concerned, stands closer to the mediating method than to the whole method.
5. The effect of the method of learning upon memory work varies in several respects:
   a. The mediating methods are conducive to rapid learning and to retention of medium permanency and reliability.
   b. The part method effects relatively rapid learning, but retention is neither reliable nor does it persist for any great length of time.
   c. The whole method requires often more time and repetitions for first learning but tends to greater accuracy and permanency in retention.

The most effective method in learning either poetry or prose is to read through the selection from beginning to end until the material is fairly well understood. In learning material of extended length and great difficulty, it is probably better to divide the material into large units which represent complete thought, to learn these units separately and to correlate them by some means which will hold the various parts together. Crafts[1] concludes that neither method will be invariably superior but that the whole method may be expected to be especially advantageous with easier and more closely related material. The relative effectiveness of either method depends upon the

[1] Crafts, L. W., Whole and part methods with visual spatial material, *Amer. J. Psychol.*, 1932, **43**, 526–534.

material to be learned, the distribution of periods of practice and the age and maturity of the learner.

5. Recall and Recitation.—It is especially important that the pupil attempt to recall frequently the ideas which he has studied. The recitation[1] not only includes recall of material, but also serves to select the items in order of importance and, through discussion, make them a part of the pupil's thinking. In the recitation there is the assurance that proper associations are formed and that the pupil is led to clarify misconceptions and false notions. The recitation also causes the pupil to use the information obtained from his study immediately upon learning it. Learning is more effective when there is frequent recall and use of the facts as soon as they are learned. The pupil should be guided in making definite classifications of materials, so that there may be a number of pivotal topics to which may be attached the main points of his work. More important still, the recitation aids in perceiving facts in relation to themselves and in their relation to study.

6. Extensive and Intensive Reading.—The relation of extensive and intensive reading to learning efficiency and retention is of practical importance. Does the extensive reader who covers a wide range of subject matter learn and retain more than one who covers more intensively a narrow range of material during the same period? Good[2] used two parallel groups of high-school pupils and measured reading efficiency by such factors as range and accuracy of information, problem-solving ability and the reproduction of ideas. Retention was determined by repeating such tests after intervals of

[1] Gates, A. I., Recitation as a factor in memorizing, *Arch. Psychol.*, 1917–1920, 6, No. 40.

Myers, G. C., Confusion in recall, *J. Educ. Psychol.*, 1917, 8, 166–175.

Myers, G. C., Recall in relation to retention, *J. Educ. Psychol.*, 1914, 5, 119–130.

Abbott, Edwina E., On the analysis of the factor of recall in the learning process, *Psychol. Rev. Monog.*, 1909, 11, No. 44.

[2] Good, Carter V., The relation of extensive and intensive reading to permanency of retention, *Ped. Sem.*, 1926, 33, 43–49.

Good, Carter V., The effect of extensive and intensive reading on the reproduction of ideas or thought series, *J. Educ. Psychol.*, 1927, 18, 477–485.

weeks and months. The investigations involved two learning situations. In one case the material of a given course was read outside of the class period, and in the other it was done within the class period under controlled conditions. One group did extensive reading on a given topic while the other concentrated its efforts on smaller reading assignments. In the case of materials read within the class period, the tests show that, from the standpoint of ability to reproduce ideas, the intensive reader has the advantage. For materials read outside of the class, the two types of readers are about equal in reproduction of ideas, although those of the extensive reading group tended to be more general. In those tests which measured problem-solving ability and the ability to answer questions involving information, the extensive reader was superior. These results indicate that if the objective is the reproduction of specific ideas, a program of intensive study is desirable, while if the aim is to develop the ability to solve problems and make generalizations, extensive reading may be recommended.

7. The Relative Values of Rote and Logical Learning.— There are many situations which demand a high degree of accuracy in reproduction. The multiplication table and various other number combinations require exactness in memorization. In the study of Latin there are rules which do not lend themselves to ready explanation, yet they must be mastered for progress in the subject. In orations, readings, plays and the memorization of poetry and quotations, exact dates in history and locations in geography, rote memorization is essential. There are many rules, principles and formulas which must be accurately memorized. However, before rote memorization is employed there should first be developed a thorough understanding and comprehension of meaning, interpretation and applications. Logical learning should, therefore, precede any attempt to memorize with a view to exact reproduction. The chief purpose of rote learning is to fixate and automatize materials which have been comprehended by the process of logical learning.

It is only when the pupil has developed meanings and comprehension of material that learning becomes a part of his thinking process. In deriving meanings from materials the most important requirement is comprehension and speed in reading. Good reading is primarily a process of thinking in response to the printed page. Poor reading ability of high-school and college students accounts for many failures. Reading as a process of logical learning should, therefore, be developed in the elementary schools and emphasized in high school and college.

It is questionable whether bright or dull children learn more easily by rote. Since the bright pupil is more capable of seeing meanings and relationships in materials, he is usually better at rote learning than the dull pupil. However, it is probable that the dull pupil will choose to learn by rote if given an opportunity because he finds it more difficult to comprehend meanings.

Whether pupils will learn by the rote or logical process will depend a great deal upon teaching objectives and the nature of examinations. If the objective in teaching is to require the acquisition of isolated facts and to demand their reproduction through examinations in the words of the text or lectures, rote memorization will be adopted by pupils, even though they may prefer restatement of materials in terms of their own reactions. When teachers stress meaningful associations and teach facts in relation to cause and effect or by the problem-solving method and construct examinations to test comprehension, pupils will normally use the logical process. Learning of all meaningless material will naturally require the rote process, while meaningful material may be acquired either by rote or logical learning. Some forms of the traditional examination stress rote memorization, while others require power of organization and comprehension. New type examinations generally cover a wide range of information and require thought rather than exact memorization. Completion, best-answer or multiple-choice questions tend to stress logical learning.

Rote memorization of material is of limited value because it minimizes interpretation and generalization. Logical learning

because of its associations, causal relations and basis for reflective thinking is indispensable.

E. Summary

Rote learning is essentially a process of exact memorization of either meaningless or meaningful material. It is primarily a mechanical process, the efficiency of which is chiefly determined by the time and number of repetitions required to learn. In logical learning there is an attempt to comprehend words and thoughts without exact memorization; the materials are always meaningful.

The improvement process is best described by an analysis of curves of improvement which graphically show increased efficiency with continued training. Improvement is characterized by irregularity of performance during successive training periods. There are initial rises, fluctuations and plateaus. In meaningless materials initial rises are more pronounced and are accompanied by numerous marked fluctuations. In meaningful materials the initial rise is less marked, accompanied by fluctuations which appear more slowly. The difference between the characteristics for the two types of material may be explained on the basis of the opportunity for associations in meaningful materials.

Continued practice tends to decrease rather than increase individual differences of pupils undergoing training. The learning of bright children is characterized by fewer repetitions and more ability in avoiding errors. Increase in age indicates within limits a corresponding increase in ability to profit by training. The differences between boys and girls in learning are probably due to types of material and previous training rather than to differences in innate ability.

Guidance, which is the most important factor influencing the economy of learning, includes specific practice upon functions to be improved, constant measurement of progress as learning continues and the provision of impelling incentives.

Learning is more economical if practice periods are distributed over long intervals. Although there is an increase in effort

required to learn lengthy materials, they are more economical than short materials. The whole method is superior to the part method, but the mediating method, which includes the advantages of both, is most efficient.

The pupil should be encouraged to recall facts and ideas at frequent intervals as a means of organizing and evaluating assignments. The recitation is important because it enables the pupil to put ideas and facts to use as soon as learned. Extensive reading tends to favor the development of generalizations and problem-solving ability, while intensive reading tends to enhance the acquisition and retention of specific facts. Because logical learning requires understanding and application it should be stressed in all subjects.

CHAPTER VIII

IMPROVEMENT IN MENTAL LEARNING (*Continued*)

PROBLEM SOLVING AND REFLECTIVE THINKING

Rote memorization and comprehension of material primarily require receptive rather than constructive thinking. Problem solving requires not only the acquisition of facts but that they be studied in their relationship and application. Although the solution of problems is dependent upon the acquisition of information, the school in furnishing this information often minimizes original and creative thinking. As early as 1889, Baldwin[1] pointed out that while the development of problem-solving ability was one of the chief aims of education the schools continued to emphasize the memorization of facts and principles. He said:

> The culture of reasoning has been generally neglected in our methods of teaching. The object of teaching seems to have been to fill the memory with facts and truths of a subject rather than to develop the power of original thought and investigation. Even in teaching thought studies memory has been brought into activity more than thought. The mind has too often been regarded as a capacity to be filled rather than an activity to be developed.

Questions of doubt and perplexity exist on every hand, but it is only when one is confronted with a perplexing situation that it becomes a problem for him and the difficulty creates a need which requires effort for fulfillment. Some problems evoke definite processes of solution that are readily accepted while others result in solutions which are tentative and controversial.

Success depends upon ability to recognize and solve difficulties and to adjust oneself to the increasing complexity of life. Practical problems vary in importance from some

[1] BALDWIN, JOSEPH, *Elementary Psychology and Education*, New York, Appleton, 1889.

momentous decision which affects the entire process of living to trivial questions of daily occurrence. There are personal problems, which involve man's relation with himself, such as religious and vocational problems; social problems, or man's relation with his fellowmen, as language, education and business; scientific problems in such fields as chemistry, physics and astronomy; and mathematical problems such as those in arithmetic, algebra and geometry. Problems may further be classified as subjective or objective, practical or speculative.

A. Problem-solving Ability

Most individuals possess problem-solving ability in some degree. Investigations have been made in all grades of the public school, and this ability was evident in each grade. Heidbreder[1] found the ability present at three years. Binet[2] tested three-year-old children for intelligence. The development of problem-solving ability is probably concomitant with the growth of intelligence. Children's lives are full of activity and they are constantly developing projects and attempting to solve problems of their own. In their process of living, playing and acquiring experience they frequently work with definite purposes in mind and learn to evaluate ideas and objects in order to overcome obstacles.

The process of problem solving is essentially the same for children as for adults.[3] It is easy for the adult to form the impression that the child does not think or that his thinking is a different process. The child has few ideas and little experience upon which to base judgment, while the superior ability of the adult is primarily due to his larger fund of information and experience. Experiments in which first-grade children and adults reproduce Greek letters and ordinary sentences indicate that the adult has little advantage in the reproduction of

[1] Heidbreder, E. F., Problem-solving in children and adults, *Ped. Sem.*, 1928, **35**, 522–545.

[2] Binet, Alfred, *The Psychology of Reasoning*, Chicago, Open Court Pub. Co., 1907.

[3] Dewey, John, Reasoning in early childhood, *Teach. Coll. Rec.*, 1914, **15**, 9–15.

unfamiliar Greek letters, but his superiority is marked in reproducing those with which he is familiar. The child's restricted environment provides little opportunity for the accumulation of ideas. Having no ideas at birth, he must gradually accumulate them over a period of years. Each idea must be tested with time and experience, and such effort for the child means a great deal because his time is chiefly engaged in learning mechanical processes such as walking, talking, reading and writing.

The tendency for children to be inaccurate in their observations causes errors in judgment. Their range of observation and attention is narrow, and, since their judgment and constructive imagination are undeveloped, they have not reached the stage of maturity where reasoning is efficient. The child's ideas are soon exhausted and his attention is diverted by other stimuli regardless of their relevancy. There is no impelling incentive demanding correct thinking and no momentous results depending upon the child's reasoning; hence children see no need to concentrate intensively upon problems requiring unusual effort.

The child has not learned to search for essentials and to analyze[1] and consider various parts of a problem. His thinking is not organized and he has no criteria for judging the accuracy of his thoughts. The difference between the thinking of the child and of the adult has led to the belief that the child thinks little before the age of adolescence.[2] In reality the adolescent has passed through the period of childhood play and development which has broadened his views and experiences, thus permitting him to think in much the same manner as the adult.

Heidbreder[3] found that although children of three years could solve problems, the ability to recognize problems as such was lacking at this age. Problems were recognized at four years and the ability was present in all children between the ages of six and ten. She also found that problem-solving ability

[1] Thorndike, E. L., *Notes on Child Study*, New York, Macmillan, 1901.
[2] Dewey, John, *How We Think*, Boston, Heath, 1910.
[3] Heidbreder, *op. cit.*

increases steadily with age. Lindley[1] conducted a similar study with 471 children and 300 adults, and studied problem-solving ability by means of puzzles and questionnaires. He concluded that persons with pronounced interest in puzzles made a favorable showing intellectually and ranked high for inventiveness and originality. Puzzle interests attained their greatest popularity at the age of twelve. Children of the third grade showed little tendency to profit by errors and frequently lapsed into former movements. With increase in age there was more accuracy, better analysis and a greater tendency to profit by errors.

The following conclusions derived by Heidbreder[2] present the important differences between adults and children and the growth of problem-solving ability.

1. The general ability to solve problems increases with age. The problems represented degrees of difficulty which retained the same rank order at the different age levels.

2. Responsiveness to problems as such also increased with maturity. There were no observable signs of its occurrence in the three-year-old group; it was distinctly, but occasionally, present at the fourth-year level; it was very prominent in the six- to ten-year level and had become definitely associated with the self-feelings; it was exhibited in adults and also attached to the self-regarding sentiments which, however, expressed themselves in less assertively emotional forms.

3. There was a gradual emergency of a general form pattern or mode of procedure which became more definite, but never rigidly set as age increased. This pattern appeared in the midst of a great diversity of reaction so far as the particular procedures and the concrete materials of thought were concerned. It revealed itself chiefly in two ways:

(1) In reaction-time curves which were quite formless among young children but which attained a fair degree of definiteness and regularity among adults; (2) behavior differences which indicated a narrower set and somewhat more uniform procedure in adults than in children.

4. There were age differences both in the frequency with which reasons occurred and in the kinds of reasons employed. The differences were such as to indicate a development from less adaptive to more adaptive modes of response.

[1] Lindley, E. H., A study of puzzles with special reference to the psychology of mental adaptations, *Amer. J. Psychol.*, 1887, **8**, 431–493.

[2] Heidbreder, *op. cit.*

5. There was a gradual change, through age groups, from a more subjective to a more objective attitude toward the problem as a whole.

The important mental processes manifest themselves at an early age and there is a continuous development through adolescence. Problem-solving ability appears very early in the life of the child. With increase in age there is a corresponding growth in mental processes, which are accompanied by a wider range of experience. The acquisition of experiences requires time. Age provides opportunities and incentives for their accumulation and it is probable that problem-solving ability continues to develop through middle age with no decline until the period of senility.

B. The Technique of Problem Solving

The technique of problem solving is reflective thinking. Directed thinking results in some definite decision or positive activity. Many situations require little conscious effort and are provided for by the process of habit. Another type of thinking, which may be termed *scientific*, requires understanding of the various parts of the problem in relationship to the whole and a painstaking evaluation of pertinent data before there is an attempt at generalization. Still another level of thinking is a process of careful observation, analysis and synthesis by means of active imagination, which results in refinement and increase in knowledge. This type is a process of developing general unifying principles and may be termed *creative thinking*. To observe carefully and to think judiciously require effort which few are willing to give.

1. Experience, Habit, Association, Trial and Error.— Experiences are the prime requisites for reflective thinking. Experiences may be primary or secondary. Primary experiences consist in activities in which one has participated, while secondary experiences are the activities in which the individual has taken no part but has adopted from the experience of others. Primary experiences are comparatively few and are limited by the immediate environment, while secondary experiences are infinite in scope and restricted only by the

mental capacity and training of the individual. They are obtained largely by observing, reading and listening. When a statement is heard or read that does not accord with the primary experiences of the individual, confidence is sometimes lost and the statement is rejected as untrue. It is, therefore, necessary in teaching to bridge the gap between the primary and secondary experiences of the pupil.

The point of view that reasoning is dependent upon previous habits and associations is confirmed by experiments dealing with the solution of problems. Kline and Anderson[1] found that problems which involve reasoning ahead or with future dates are more easily solved than those which require reasoning backward because we are accustomed to think and reason according to sequence of events. Thorndike[2] shows that reasoning is essentially the organization and integration of past experience and habits rather than any particular ability. He says: "Any disturbance whatsoever in the concrete particulars reasoned about will interfere somewhat with the reasoning, making it less correct or slower or both." His conclusion is based upon a study of 97 graduate students divided into three groups. He used as material two sets of tasks in algebra, each pair of tasks demanding the same application of the same principle, but the situation in one case was that with which the ordinary associative habits had been made, while in the other case the concrete particulars were somewhat altered and less familiar. The results of this experiment showed that even slight changes from the customary procedure impede the thought process. Clark[3] also concluded that the process of reasoning is largely a matter of using previous associations. In the early processes of thinking, habits are formed and are based upon the processes of association and recall of familiar circumstances pertinent to the immediate problem.

[1] KLINE, L. W., and P. A. ANDERSON, The role of habit in reasoning, *School, Sci. & Math.*, 1926, **26**, 156–167.

[2] THORNDIKE, E. L., The effect of changed data on reasoning, *J Exper. Psychol.*, 1922, **5**, 33–38.

[3] CLARK, R. S., An experimental study of silent thinking, *Arch. Psychol.*, 1922, **7**, No. 48.

Several experiments in solving riddles and puzzles have been conducted to determine whether the solution of problems is performed chiefly by the trial-and-error method or whether certain principles of reasoning are discovered and applied in the solution. Kline and Mather[1] by means of mechanical puzzles observed the ways in which principles are likely to be discovered and applied in solving concrete problems. The material of the experiment consisted of cardboard puzzles which formed a related series beginning with simple forms. Each succeeding puzzle contained more pieces and was more complex, but was directly related to the preceding ones. Their results showed that at first the trial-and-error method prevailed, but that trial-and-error responses were gradually superseded by those of control and purpose when the function of a piece in the puzzle was recognized. Garth[2] also studied 331 high-school, normal-school and college students, using riddles as a basis of measurement. Ten selected riddles were used; the subjects were given a definite time on each riddle and were requested to record all guesses that came into their minds. His study indicates that the trial-and-error method prevails in riddle solution.

Trial and error is not, however, the haphazard process in problem solving that the term implies. Experience furnishes guidance which prevents errors and produces success. Suggestions are tried out and errors eliminated until success is attained. One of the most striking differences between human beings and lower animals in trial-and-error learning is the elimination of random effort by means of reflective thinking. The cat in the puzzle box and the rat in the maze aimlessly seek a way out of the difficulty and arrive at a solution primarily by accident. Man uses reasoning, tries out suggested solutions and eliminates errors until success is achieved. Experience guides his actions and determines the scope of his investigation.

[1] KLINE, L. W., and J. E. MATHER, Psychology of puzzle problems, *Ped. Sem.*, 1922, 29, 269–282.

[2] GARTH, T. R., The psychology of riddle solutions, *J. Educ. Psychol.*, 1920, 11, 16–33.

2. Steps in Problem Solving.—Irrespective of the subject matter, the procedure in the solution of a problem includes the following five steps according to Dewey:[1]

1. A felt difficulty.
2. Its location and definition.
3. Suggestion of possible solution.
4. Development by reasoning of the bearings of the suggestion.
5. Further observation and experiment leading to its acceptance or rejection; that is the conclusion of belief or disbelief.

Some writers have increased or decreased the number of these steps. Burtt[2] claims that there are types of problems which do not have a fifth step. However, a careful analysis of most complete acts of thought shows that they resemble closely Dewey's classification.

a. Sensing the Difficulty and Its Location and Definition.—A problem arises from a conscious difficulty and the tendency of uncritical thinking is to arrive hastily at a conclusion. The problem must be accurately located, defined and delimited. There may be elements in the problem which do not come to light until further study. Initial observation is essential to an understanding of the difficulty and to the prevention of random thinking. Consequently, judgment must be suspended until the exact nature of the problem can be determined and its boundaries established. The effective collection and evaluation of data depends upon accurately locating and defining the problem. Dewey states "that the essence of critical thinking is suspended judgment; and the essence of this suspense is inquiry to determine the nature of the problem before proceeding to attempt its solution."

Pupil response in the classroom may not be satisfactory. There may be, for example, evident lack of interest on the part of pupils in the subject taught. The problem may be centered in the curriculum or the difficulty may be in the method of

[1] Dewey, *op. cit.*

[2] Burtt, E. A., *Principles and Problems of Right Thinking*, New York, Harper, 1928.

teaching. Helseth[1] studied a class of seventh- and eighth-grade pupils who were required to locate and formulate questions for discussion in history. Her results show that the ability to locate and define problems is definitely improved by practice and training.

b. The Development of Suggestions.—When the problem has been located and delimited, suggestions for possible solution may be considered. Past experience and previously attained knowledge checked by critical observation will suggest solutions. Facts which promote the suggestions must be selected and arranged. The result will be several suggested hypotheses which serve as provisional bases for further thinking. These hypotheses further clarify the problem and supply the materials for inference. The heart of the problem-solving method is found in the development of these suggestions and their implications.

There is need for more exact information concerning reflection at this stage. The terms *intuition* and *insight* are sometimes used to describe the process of suggesting new solutions. It is probable that insight is the occurrence of the suggested solution and its rapid development by reasoning. Bulbrook,[2] in an experiment to determine the nature of insight, concluded that there is no distinctive process which can be identified as insight. It was further shown that both those who solved the problems rapidly and those who solved them slowly followed the same process. This process consisted in suggesting probable solutions and trying them out until correct ones were reached.

It is probable that information and experience are the most important elements in the ability to suggest solutions. Tilton,[3] in an experiment involving problem-solving ability of 250 boys, found that those who know most are best able to reason. In

[1] HELSETH, INGA O., Children's thinking, *Teach. Coll. Contrib. Educ.*, 1926, No. 209.

[2] BULBROOK, MARY E., An experimental inquiry into the existence and nature of insight, *Amer. J. Psychol.*, 1932, 34, 409–453.

[3] TILTON, J. W., The relation between association and the higher mental processes, *Teach. Coll. Contrib. Educ.*, 1926, No. 218.

other words, there is no reason to believe that "fact getters" are at a disadvantage in solving problems.

c. Testing Hypotheses by Reasoning.—Reasoning implies that if ideas are adopted certain consequences will follow, but they must still be recognized as tentative. The central factor in reasoning is that a thing sensed suggests a thing not sensed, and, if the relationship warrants, it may signify or indicate the thing suggested.[1] While sitting in a warm room, one may observe frost forming on the window pane. This observation suggests that the weather outside is turning colder, also that there is is an abundance of moisture in the air within. Past experience concerning such a case comes to mind to assist and support the suggestion. In this case some objective test can be made to verify the conclusion but in other cases objective tests may be impractical. One may, however, apply certain tests to one's belief, which are more or less subjective though none the less accurate. All beliefs, however subjective, may be verified by substantiating evidence which may in turn be more or less subjective in itself.

Dewey states that "thinking is that operation in which present facts suggest other facts (or truths) in such a way as to induce belief in the latter upon the ground or warrant of the former." If one reflects upon a principle and seeks supporting evidence for new data to develop the suggestion, one has taken the next step for proving or disproving it. This attitude of suspended conclusion, together with the mastery of the various methods of searching for new materials to prove or disprove the first suggestions which arise, is essential to problem solving. Data must be assembled according to the needs of the problem, weighed for their pertinence and classified before conclusions can be drawn. Insufficient, irrelevant data lead to erroneous conclusions and impossible solutions. The solution itself, after the method has been decided upon, is largely a mechanical process following fixed habits of performance.

d. Evaluating the Solution by Observation and Experiment.—Sound reasoning requires some experimentation for confirma-

[1] DEWEY, *op. cit.*

tion. This step implies that, if problems are of such a nature that the solution accepted does not actually work, a new solution may be attempted. Burtt,[1] however, points out that in some problems this step is necessarily lacking. There are problems of pure mathematics which have no reference to the material characteristics to which the results might be applied, as, for example, proving that the sum of the three angles of a triangle equals two right angles, and also problems of such a type that action in accordance with the suggested solution terminates the act of reflection. He cites the case of a man confronted by the problem of being downtown in half an hour to keep an appointment. Three possible means of transportation are open. He may take a bus, street car or the elevated railway. However, as soon as he has committed himself to one suggested solution, he precludes the possibility of trying others.

In most types of problems the reflective process is not completed until the solution has been tested by experimentation or observation. If the solution is rejected, the problem can be kept in mind until another solution is developed and again tested. Most of the practical problems fall in this latter type, as do all problems of scientific experimentation and discovery. When the reflective process cannot be validated by experimentation, the following criteria suggested by the Columbia Associates in Philosophy[2] may be applied to the derived belief or hypotheses: (1) clarity—a good belief is unambigious; (2) consistency with the facts—a good belief is founded upon extensive and accurate observation; (3) consistency with other beliefs—there is a presumption against a belief that conflicts with other beliefs which are well certified by experience; (4) utility—a good belief is often distinguished by its usefulness in suggesting other beliefs; (5) simplicity—that belief is best which makes fewest assumptions. It is important that every inference be a tested inference, but in cases where this is not possible one should discriminate between conclusions derived from tested evidence and those which are not.

[1] Burtt, *op. cit.*

[2] Columbia Associates in Philosophy, *Introduction to Reflective Thinking*, Boston, Houghton Mifflin, 1923.

With truth itself a relative term, here today and given up tomorrow for that which in the last analysis more nearly approaches the greatest probability, we are playing essentially the same game that our ancestors did, namely the best guess. Only we insist today in scaffolding our guesses with masses of objective data accepting for the present at least the theory that the greater objectivity the more probable the accuracy of the solution proposed.[1]

Thus the problem-solving method attempts to adapt itself to objective evidence, and we trust its conclusions in the degree to which we think it succeeds in such adaptation.

3. **Induction and Deduction.**—Induction and deduction are employed in the solution of every problem. Although the processes are so closely related that it is difficult to separate them in practice, each has its particular function. Induction is the process in which judgments pass from the specific to the general, while deduction is the process in which judgments pass from the general to the specific. Induction is a process of discovery, while deduction is a process of invention. Most stories and plays are developed inductively so that each successive chapter or act adds something to the preceding parts in such a manner that interest is sustained until the climax. Geometry as it is usually presented is a good example of deduction. A proposition is stated and data are gathered to prove or disprove the statement. The deductive method of problem solving is often used. Edison[2] in speaking of his invention of the electric lamp stated:

During all these years of experimentation and research I never once made a discovery. All of my work was deductive, and the results I achieved were those of invention pure and simple. I would construct a theory and work on its lines until I found it was untenable. Then it would be discarded at once and another theory evolved. This was the only way for me to work out the problem. I speak without exaggeration when I say that I have constructed three thousand different theories in connection with the electric light, each one of them reasonable and apparently likely to be true. Yet in only two cases did my experiments prove the truth of my theory.

[1] Waitt, R. E., A plea for a more appreciative cooperation between scientist and philosopher in education, *Educ.*, 1929, 49, 513–521.

[2] Lathrop, G. P., Talks with Edison, *Harper's Magazine*, 1922, 80, 425.

Both processes have their particular functions and yet it is almost impossible to have one without the other. In problem solving the mind jumps so rapidly from one process to another that it is difficult to determine where one ends and the other begins. When presented with a problem, the mind at once formulates some hypothesis of solution—deduction—then tries to fit the known parts together inductively to determine whether the hypothesis is correct and the solution can be performed. Induction is a process of proving deduction and deduction is an hypothesis upon which induction may work. Every thought process is both inductive and deductive and may be viewed either as induction or deduction according to the point of view in interpreting it.

C. Attempts at Objective Measurement

Many investigators believe that problem-solving ability is best measured by unusual situations and have attempted measurement by means of puzzle problems. Peterson[1] experimented with what he termed a rational learning test but later concluded that it was more of a measure of intelligence than of rational learning. Bonser[2] divided problem-solving ability into four divisions including mathematical judgment, controlled association, selective judgment and literary interpretation, and prepared tests for the fourth, fifth and sixth grades. His tests required analysis of the problem, the recall of appropriate laws or principles, the recognition of the relation between the principle and the new situation, selection on the basis of similarity and relevance and testing the results by experience. He concluded that, since the scores of younger children in a particular grade were usually highest, the tests were largely measures of innate ability.

Both Herring[3] and Zyve conceived the idea that problem-solving ability may best be measured on the basis of scientific

[1] Peterson, Joseph, Experiments in rational learning, *Psychol. Rev.*, 1918, **25**, 443–467.

[2] Bonser, F. G., Reasoning ability of children of the fourth, fifth and sixth grades, *Teach. Coll. Contrib. Educ.*, 1910, No. 37.

[3] Herring, J. P., The derivation of a scale to measure some abilities in scientific thinking, *J. Educ. Psychol.*, 1919, **10**, 417–432.

thinking. They wished to make tests that would reflect the innate ability of pupils rather than achievement in school subjects. In brief they wished to test the ability of the individual to cope with a relatively novel situation. Each chose from the field what he considered the important abilities and prepared exercises for their measurement. Herring's test was designed for both high-school and college students while Zyve's test[1] was prepared specifically for college students. Herring's test included the following eleven abilities:

1. Value. The ability of pupils to judge of the relative values of different problems.
2. Feasibility. Ability to judge whether a problem can be solved or not.
3. Definition. Ability to distinguish a good definition from a bad definition.
4. Clarity. Ability to recognize ambiguity.
5. Statistics. Ability to know when statistics are needed in the proof of a statement or solution of a problem.
6. Relevancy. Ability to select the facts that relate to the problem and reject those that do not.
7. Recording. Ability to select the best methods of recording facts.
8. Comparison. Ability to distinguish good from bad comparison.
9. Classification. Ability to recognize the presence of something foreign in a classification.
10. Arrangement. Ability to arrange members in useful sequence and distinguish between good and bad arrangement.
11. Sufficiency. Ability to judge whether the data are sufficient for the purpose.

Zyve's test included exercises designed to measure clarity of definition, suspended *versus* snap judgment, experimental bent, discrimination of values, detection of fallacies, reasoning, accuracy of observation, induction, deduction and generalization, accuracy of understanding, interpretation and caution. It is evident that the two tests measure essentially the same types of abilities. The following samples taken from Zyve's test are typical of the exercises used:

[1] Zyve, D. L., A test of scientific aptitudes, *J. Educ. Psychol.*, 1927, 18, 523–546.

Clarity of Definition

Rank the following definitions of a bow according to merit, *i.e.*, write 1 next to the best definition, write 2 next to the second best, etc. The poorest will receive the rank of 4.

———A bow is a weapon used by primitive people either in war or for hunting small and even large game by means of arrows.

———A bow is a piece of wood which after having been bent into an arc is used for shooting arrows.

———A bow is a weapon well known in every country from time immemorial.

———A bow is a weapon made of a strip of wood or other material the two ends of which are connected by a cord by means of which arrows may be projected.

These definitions were ranked by several faculty members of the science and engineering departments of Stanford University, where the test was standardized, and only those definitions were adopted upon which unanimity of the judges was secured.

Suspended versus Snap Judgment

Put a check next to the correct answer given below: What is the population of this country going to be in 3000?———About 150 million;——— about 300 million;———about 500 million;———over 500 million; if unable to answer put a check here———.

It is clear that no correct answer can be given to this question and those who have the tendency to suspend judgment when data are incomplete will admit their inability to answer the question.

Other tests include those by Dale,[1] who devised several forms so that improvement might be determined. Since her tests correlated closely with tests of intelligence, she concluded that they provided reliable tests of problem-solving ability and could effectively be used with pupils between ten and sixteen years of age. The following is a sample of the exercises included in her tests:

[1] Dale, Barbara A., Group test in reasoning ability, *Brit. J. Psychol.*, 1926, 16, 315–337.

I am older than Mary and younger than John. Draw circles around the numbers of the correct sentences.

1. John is younger than Mary.
2. Mary is younger than John.
3. Mary is older than John.
4. I am the oldest of the three.
5. Mary is the youngest of the three.

The tests by Herring, Zyve and Dale have been partially standardized and have a significant degree of reliability and validity. It is probable that all of these tests measure abilities which are closely associated with general intelligence. They are useful in measuring innate ability and aid in the classification of pupils. There is needed a series of graded tests for elementary and high-school pupils so that teachers may determine problem-solving ability and measure improvement resulting from special teaching methods. There is also need for the development of problem-solving tests in school subjects so that the ability may be measured and emphasized in all fields of subject matter.

D. Training in Problem Solving

The teacher is supposed to make special effort to stimulate eager curiosity in the child by his methods of teaching and yet in his own daily life is likely to have fixed limitations of routine thinking. Research and problem solving are so closely associated that if we advocate problem solving for pupils we must also encourage research for teachers. Curiosity is natural and research aids in satisfying that curiosity. The unfortunate circumstance is that in the process of teaching or administration the eagerness to solve problems is dulled and thwarted.

Teachers can yet be found who believe that their chief task is to impart information and who regard the child as a storehouse for the accumulation of isolated facts. Children are shielded and protected from thinking and made to conform and reproduce facts until the natural spontaneous tendency to solve problems is almost killed. The child's attempts to think out things for himself are met by intolerance and even ridicule from

parents and teachers. Research from the standpoint of teaching requires orderly arrangement of outlines, collection of appropriate readings and the construction of questions designed to evoke creative thinking. The teacher should be continuously on the alert to add new data to her courses and to make applications to immediate problems. The class should be conducted so that free and critical discussion of topics and problems may be encouraged. Encouragement from the teacher at the appropriate stage of problem solving is of vital importance. Help given too soon cripples initiative and ability. When help is given too late, interest is lost. The child who can work without encouragement is rarely found. The teacher must learn the psychological moment when his help is needed. Ability to stay with a task and see it completed can be taught but requires the highest type of teaching.

Investigations indicate that problem-solving ability may be improved by guidance and practice. Simpson[1] conducted several experiments with fifth- and sixth-grade pupils to test the effectiveness of training in the technique of thinking. Children of these grades were required to define simple words and later were given specific practice in logical definitions in order to determine the amount of improvement resulting from specific training, as well as the ability of pupils to transfer this training to the definition of similar words. He found that children of these grades are capable of understanding the technique of logical definition and can apply it in the definition of other words. Helseth[2] studied seventh- and eighth-grade pupils throughout a year's course in history. She wished to determine if children could effectively use their own questions for study, to find a means of fostering good thinking and to determine whether children could themselves improve their own methods of study. She found that the children had shown distinct improvement in speed of locating facts, in formulating questions from material read and in ability to solve problems.

[1] Simpson, B. R., Training in the technique of thinking as a means of clearer thinking, *School & Soc.*, 1923, 18, 358–360.

[2] Helseth, *op. cit.*

Newcomb[1] performed an experiment with seventh- and eighth-grade classes to determine whether there might be some general principle which would apply to all types of arithmetic problems. His material consisted of 20 prepared problems arranged in order of their difficulty. Control groups were used and the teachers of these classes knew nothing of the proposed method and taught in the usual way. Both the experimental and control groups were given the Stone reasoning test as an initial measure and again at the end of six weeks. The experimental groups were required to solve one problem each day for six weeks according to the following plan:

1. Understand each word in the problem.
2. Read the problem intelligently.
3. Perform the operations with speed and accuracy.
4. Tell what is given and what is required.
5. Select the different processes to be used.
6. Plan the solution wisely and systematically and check readily.

As a further means of guidance each pupil of the experimental group was also provided with a separate solution sheet for each problem having spaces for the following items:

1. Statement of the problem.
2. How to read the problem.
3. The data given.
4. The data required.
5. The processes necessary for the solution.
6. The approximate answer.
7. The solution proper.
8. Checking results.

Newcomb found that the experimental groups showed a superiority over the control groups by 13.9 per cent in speed, 3.3 per cent in accuracy and 15.3 per cent in speed and accuracy combined. He believes that many of the difficulties encountered by pupils in problem solving are due to incorrect methods of attack, and that with definite training and guidance marked improvement may be expected.

[1] NEWCOMB, R. S., Teaching pupils how to solve problems in arithmetic, *Elem. School J.*, 1922, 23, 183–189.

The part played by the teacher in developing problem-solving ability is of extraordinary importance. To illustrate the function of a good teacher in developing problem solving, Parker[1] cites a lesson taught by one of the teachers in the University of Chicago Elementary School. A seventh-grade class was reviewing the geography of the United States and attention had been directed to the question of sugar production in this country. The question was: "Should the United States produce its own sugar?" Parker has characterized the method used by the teacher in conducting this class as follows:

1. She created an intense problem frame of mind by disconcerting the pupils with a graphic representation of the contrast between our large consumption and relatively small production of sugar.
2. She had the problem for discussion clearly formulated and wrote it on the board.
3. She kept the problem clearly before the pupils by frequent reference to it as written.
4. She encouraged suggestions from the pupils not only in matters of fact or data, but also in the matters of procedure, *i.e.*, in regard to such questions as "What shall we do next?" or "How can we find out about that?"
5. She encouraged careful evaluation and criticism by the pupils of the various suggestions.
6. She gave practice in the use of scientific treatises as the source of data and as a means of verification.
7. She encouraged the attitude of desiring verification of suggestions by reference to standard authorities.
8. She conducted the lessons at a deliberate pace so that the pupils were required to think before answering. As a special device in this connection she occasionally said, "When you have your mind made up you may rise," and then waited until most pupils had risen.
9. She kept the discussion organized along definite lines by outlining on the blackboard the various important suggestions that were made and then holding to the order in which they had decided to pursue the discussion. In this way the main problem became analyzed into a number of subordinate problems which were disposed of in an orderly manner.

The role of the teacher in developing problem-solving lessons has been outlined by Parker as follows:[2]

[1] Parker, S. C., Problem-solving or practice in thinking, *Elem. School J.*, 1920, 21, 16–25, 98–111, 174–188, 257–272.

[2] *Ibid.*, 267.

To stimulate and assist pupils in reflective problem solving the teacher should:

1. Get them to define the problem clearly.
2. Aid them to keep the problem in mind.
3. Get them to make many suggestions by encouraging them
   a. To analyze the situation into parts.
   b. To recall previously known similar cases and general rules that apply.
   c. To guess courageously and formulate guesses clearly.
4. Get them to evaluate each suggestion carefully by encouraging them
   a. To maintain a state of doubt or suspended conclusion.
   b. To criticize the suggestion by anticipating objections and consequences.
   c. To verify conclusions by appeal to known facts, miniature experiments and scientific treatises.
5. Get them to organize the material by proceeding
   a. To build an outline on the board.
   b. To use diagrams and graphs.
   c. To take stock from time to time.
   d. To formulate concise statements of the net outcome of the discussion.

The program for improving problem-solving ability should be extended through undergraduate years of college and further emphasized in the graduate schools where it would stimulate research and the problem-solving attitude. If individual initiative and resourcefulness are to be developed, the student should be placed in the role of investigator. He should learn to gather materials, to discriminate, to organize and to draw conclusions and useful applications from an inductive method of approach. Formal courses can only present facts and impart information. Courses should be supplemented by requiring students to develop individual projects and problems arising out of class discussion and readings.

E. Summary

Problem solving demands the exercise of choice and judgment and requires constructive rather than receptive thinking. It is differentiated from other forms of learning in that it requires individual initiative, resourcefulness and creative thinking where purpose and flexibility are everywhere evident. Most

individuals possess problem-solving ability in some degree. The ability is probably inherited, but may be improved in its expression by guidance and training. It appears very early in the life of the child, probably before the age of three years, and there is a continuous development through adolescence. With additional experiences due to increase in age it is conceivable that the ability might gradually improve through maturity with no decline until senility.

The technique of problem solving is reflective thinking which is based upon the primary and secondary experiences of the individual. In problem solving the individual uses previously formed habits and associations which guide him in the process of solution. Reasoning is essentially the coordination and integration of previously formed habits and associations. In the process of solution trial-and-error responses at first predominate, but are gradually supplanted by purposive thinking and control when the relationship of the elements in the problem have been determined. The steps involved in problem solving include: (1) sensing the difficulty and its location and definition; (2) the development of suggestions; (3) testing hypotheses by reasoning; and (4) evaluating the solution by observation and experiment. The procedure includes both the inductive and deductive processes.

Problem-solving ability may be measured by objective tests and is closely associated with general intelligence. Tests have been designed to measure ability to cope with a relatively novel situation which is independent of training and environment. They are useful in classifying pupils and in determining improvement which has been produced by training. The ability to solve problems may be cultivated and improved and every school subject with proper guidance may become a means for its development. The most satisfactory way for the school to make its teaching effective is by the development of a method of problem solving which will remain long after the pupil's factual knowledge has become obsolete.

CHAPTER IX

THE PERMANENCE OF LEARNING

Good learning is the best assurance of good retention and, if improvement has been brought about in accordance with the principles of economical learning, a high degree of retention may be expected. In many schools emphasis is given to the memorization of facts and principles and teachers believe that the most effective means of measuring retention is by the ability of pupils literally to reproduce lectures and readings. This method, however, overlooks some of the most important elements of teaching, which include attitudes, problem-solving ability and habits that are not revealed by examinations which stress only factual memory. Further, it is probable that many materials taught in the classroom should be forgotten so that the pupil's mind may be free from details which have little significance or are easily relearned.

Retention may range from absolute certainty, as when a definite response is elicited by a stimulus, to such indefiniteness that many stimuli fail to evoke the desired reaction. Vivid experiences may, after a lapse of time, become so vague that many stimuli fail to revive them. There may be an entire absence of any recognizable response when, through some mental process at a more remote time, the whole experience may correctly be recalled. Some part of the original experience was present and, provided there are sufficient associations, it may be reproduced. Retention is not a distinct and separate function of the mind, but is a significant aspect of it. Without retention there could be no basis for thinking, nor ability to solve new problems as they arise. The school should train the child so that he may develop and retain groups of experience. upon which to build thought.

A. The Measurement of Retention

Retention may be measured by any one of three major methods: (1) the relearning method, (2) the recall method and (3) the recognition method. Each method includes specific techniques as follows:

1. The relearning method.
   a. Repetitions in learning and relearning.
   b. Time in learning and relearning.
2. The recall method.
   a. Number of specific recalls with the aid of cues.
   b. Recall time with the aid of cues.
   c. Promptings.
   d. Spontaneous recall.
3. The recognition method.
   a. Recognition.
   b. Reconstruction.

1. The Relearning Method.—The relearning method was devised by Ebbinghaus, who believed that, after the susceptibility of recall had been weakened by lapse of time, the best method for measuring the strength of associations was by the number of repetitions required for relearning material to the same degree it was originally learned. The relearning method as used by him consisted in learning materials to the point of one errorless reproduction and, after a definite interval of time, relearning the material to the extent it was originally learned. The difference between the effort required for original learning to the point of errorless reproduction and that required to relearn material to its original status constitutes the amount of saving. It is a method for measuring the amount of effort and time which is saved in relearning.

One technique consists in determining the difference between the number of repetitions required for original learning and the number required for relearning after a specific time; this constitutes the saving that has been effected.

Another technique is the determination of the time required for original learning as compared with that for relearning. The time required for relearning will in some cases be only one-half

the time required for learning. Worcester,[1] in a study of the retention of material learned by the auditory and visual modes of presentation, shows a saving in time of 44.44 per cent by the auditory method and 43.09 per cent by the visual method after a period of five years between original learning and relearning. Since this material had not been reviewed during the intervening period, it represents an unusually large percentage of saving in time.

2. The Recall Method.—One of the most common methods of measuring retention is by the amount of material which can be recalled immediately after learning or after the lapse of any specified subsequent time. In the technique of *specific recalls* a series of words or syllables is learned; after the lapse of a definite time, the learner is presented with certain of these same words or syllables and is required to give those which preceded or followed them. The number of correct specific recalls given when such cues are furnished consistutes the amount retained. The time intervening between the receipt of the cues and the correct recalls may also be used as a basis of determining the correctness of retention, since the stronger the retention, the shorter will be the time. This technique measures the degree of readiness of response when correct stimuli are presented.

The technique of *prompting* devised by Ebbinghaus was to wait until the subject needed aid and then to supply him with the words or syllables needed. The learner's retention is thus determined by the number of promptings needed to reproduce a given piece of material. Rather than wait until the learner needed aid, Morgan used the anticipation technique and supplied cues at the end of 2-second periods regardless of the subject's need for them. In any attempt to recall after the first presentation of the English and German words used in his study, the technique of supplying the cues regardless of need was used.

In addition to the above techniques, which measure recall by the aid of cues, the learner, after having studied given

[1] Worcester, D. A., Retention after long periods, *J. Educ. Psychol.*, 1923, **14**, 113–114.

material, may be required to give voluntarily and completely the essential items learned—*unaided recall*. This technique is used in determining the amount of the original material which can be recalled spontaneously and immediately after learning, or after any definite period. The accuracy of retention is determined by the total amount of material which can correctly be reproduced. If one has learned a list of facts and can reproduce half correctly, this fraction indicates the accuracy of his retention at that time for that material. In the Stanford Revision of the Binet test, the pupil is asked to read a paragraph which is divided into several specific thought units and then, without cues from the examiner, he is required to reproduce every thought that the passage contains. The number of definite thoughts which can be reproduced (in this case immediately) constitutes the amount of recall. This technique may be applied to any type of material, provided there is an objective basis for determining the amount of items it is desired to measure.

3. The Recognition Method.—The recognition method differs from that of recall in that items, rather than being reproduced either by cues or voluntary action, are provided and the pupil is expected to identify those which he has experienced. The process of reproducing or recalling what has been seen or heard is different from recognizing it as something which has been previously experienced. Recognition refers to the process of identifying an object or symbol as having been seen or heard before. Lehman[1] has suggested that recognition has two connotations in daily life. In one we recognize that which we have previously heard or seen, but do not know when and where, and in the other we recognize and know when and where we have had that experience before. For our purpose, however, recognition refers to the process of identification, the only

[1] Gamble, E. A., A study in memorizing various materials by the reconstruction method, *Psychol. Rev. Monog.*, 1909, **10**, No. 43.

Gamble, E. A., Rate of repetition and tenacity of impression, *Psychol. Rev. Monog.*, 1916, **22**, No. 96.

Strong, E. K. and M., The nature of recognition memory and of the localization of recognitions, *Amer. J. Psychol.*, 1916, **27**, 341–362.

consideration being that the individual is certain that the object or symbol has been previously experienced.

The recognition method is most commonly illustrated by having the individual select from a group of concepts or facts those which he has previously experienced. The method of testing may take a variety of forms. The direct question which is followed by three or more suggested alternative answers, and the incomplete statement with several answers for its completion, are most common. The usual method is to construct an objective test so that all of the answers are incorrect, though plausible, except one which the pupil is expected to identify.

The *reconstruction* technique consists in presenting a series of objects or symbols in a given order to pupils who afterwards are required to arrange them in the order in which they were first given. Gamble in her experiments used odors, colors and nonsense syllables as materials. The odorous materials were placed in small bottles of uniform size and handed to blindfolded subjects at a definite rate. When the series was completed, the bottles were disarranged and the subjects were required by sense of smell alone to restore them to their original order. If the series were not properly arranged, the performance was repeated until a correct order was made. One of the advantages of the reconstruction technique is that it is necessary to present a series only a few times because the subject tests his knowledge of the whole series after each presentation and thus more completely learns than by recognition. The technique is especially applicable with concrete and tangible materials.

4. Evaluation of Measures of Retention.—Some methods of measuring retention are not only more accurate, but are more applicable to the schoolroom situation. In general, the relearning method is most applicable for experimental purposes, while the methods of recall and recognition find their widest usefulness as measures of school achievement.

In the method of recall the efficiency of pupils is measured primarily by the fidelity with which they reproduce materials taught in the classroom. By using objective classroom examinations it is now possible to determine with considerable

accuracy the elements which it is desired to measure. Objective recall tests are usually devised in the form of simple completion of statements where cues are provided. The traditional examination, which rapidly is being replaced by objective tests, is an excellent example of the technique of spontaneous recall. Sometimes the teacher may wish to determine the degree to which pupils have learned definite facts or have become familiar with specific principles. She may also wish to determine the extent of their information as found in outside readings. In such cases, recall with or without cues is a useful measure of retention.

The prompting technique may be especially applicable in types of materials involving rote memorization of orations, poems or plays, but is rarely used in the literal sense with subjects emphasizing ideas or comprehension of material. With the prompting technique we are drilled to make reactions in about the same manner that we drill ourselves in individual study. In study when a certain response is desired, one attempts first to recall; if the desired response is not obtained, one prompts oneself by examining the material under consideration. The similarity of this technique to school and life situations makes it valuable.

Both recall and recognition have significant functions as measures of retention in school. Achilles[1] has aptly summarized the contributions of recall and recognition in the following statement:

> The field of memory might be illustrated by the crude simile of a bottle of milk. . . . The method of recall measures those items which perhaps are the "cream." The threshold for recall is high, but items which cannot be recalled may be above the threshold for recognition, its threshold being far lower. Those items which we cannot quite recall are easily recognized and lie just below the threshold for recall. The difference is one of degree. Both methods test our memory.

When it is desired to develop attitudes, concepts and problem-solving ability, the recognition method is most appropriate.

[1] ACHILLES, EDITH, M., Experimental studies in recall and recognition, *Arch. Psychol.*, 1917–1920, 6, No. 44.

In the case of recall the pupil is expected to search out and revive, either spontaneously or with the aid of cues, the previously learned material; the emphasis is clearly upon memorization. In recognition the pupil is provided with suggested answers, some of which are correct, and the stress is upon judgment and reasoning rather than upon the reproduction of ideas and facts. With renewed emphasis upon problem solving, it is evident that recognition as a measure of retention will become a fruitful method for estimating teaching and pupil efficiency in the future.

In subjects which are predominantly tangible and concrete, such as mechanics, trades, industries and map locations in geography and history, requiring pupils to restore disarranged materials to their logical order is probably one of the most effective ways of measuring the pupil's understanding, skill and application. Reconstruction, as in recognition, places emphasis upon problem solving and understanding rather than upon recall of facts and ideas, which may be reproduced although not understood.

The effectiveness of any method of measuring retention will depend upon the objectives, skills and abilities to be developed. At one time the teacher may wish to determine the degree of factual information possessed by pupils in a course, while at another she may wish to determine the ability to use facts known. For this reason several types of tests are preferable to any single type. Because tests of recall and recognition measure different aspects of abilities, every examination should include representative items from these two divisions.

B. The Curve of Retention

The curve of retention is a graphic representation of the amount retained for varying lengths of time after original learning. The curve may be plotted in either of two ways, depending upon whether it is desired to present the amount of retention positively or negatively. The curve of retention shows the amount retained in relation to the time interval, whereas the curve of forgetting indicates the amount forgotten

in relation to the time interval. The curve, when plotted according to the amount retained, shows a descending or negatively accelerated form. It indicates that a large percentage of that which is learned is forgotten very quickly, while that which remains after this initial decay diminishes at a slower and more stable rate. Theoretically, the curve of

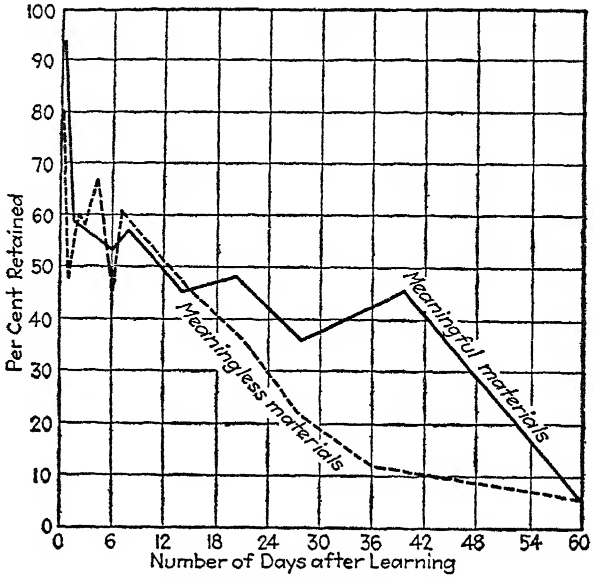


FIG. 9.—The retention of meaningless and meaningful materials as measured by the relearning method. The curve for meaningless material is based upon six studies and that for meaningful material is based upon five studies. *(From Robert A. Davis and C. C. Moore, Methods of measuring retention, J. Gen. Psychol.,* 1935.)

retention will never reach the base line although in practice it may closely approximate such a condition. It is quite likely that anything which is once learned is never completely forgotten and, given enough associations, may be reproduced either in part or in whole.

Although it is possible to plot a curve which will represent the retention process generally, the curve varies with the kind of material and the method of measurement. Studies in retention have been made with different groups, different measuring methods and different types of materials, but there has

been little confirmation of these investigations. The majority of studies have used relatively short-time intervals, and we are not certain how much will be retained over a long period of years or how much prompting or association will be necessary to produce accurate recall or recognition. Neither is it definitely known how much relearning is required for restoration of material to the original status after long periods of years.

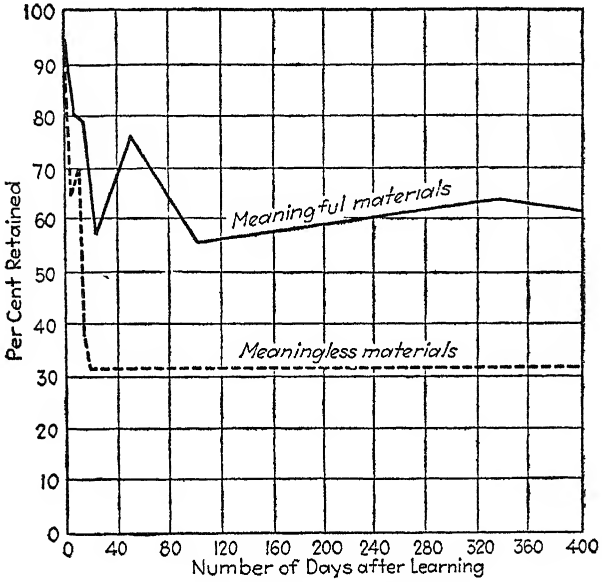


FIG. 10.—The retention of meaningless and meaningful material as measured by the recall method. The curve for meaningless material is based upon 18 studies and that for meaningful material is based upon 24 studies. (*From Robert A. Davis and C. C. Moore, Methods of measuring retention, J. Gen. Psychol.,* 1935.)

This lack of definite information has made it difficult to determine the exact nature of the curve. However, an analysis of several typical investigations is helpful. In Figs. 9, 10 and 11, are presented curves derived from studies for both meaningless and meaningful materials, as well as for the three methods of measurement. Although satisfactory comparisons of these curves cannot be made because the data are not always comparable, some general tendencies may be noted. The curve of retention has the same general characteristics whether the

method of measurement be relearning, recall or recognition, or with nonsense or meaningful materials. Usually there is a large percentage of forgetting immediately or shortly after learning, followed by an increasingly gradual decline. The curve, however, is influenced by many factors.

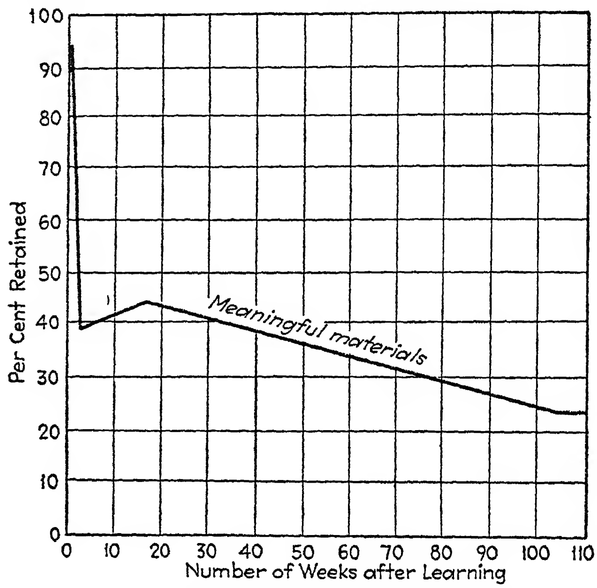


FIG. 11.—The retention of meaningful material as measured by the recognition method. The curve is based upon six studies. (*From Robert A. Davis and C. C. Moore, Methods of measuring retention, J. Gen. Psychol.*, 1935.)

C. Factors Which Influence the Curve of Retention

1. **The Time Interval.**—One of the most obvious influences on the amount of retention is the length of the interval between original learning and the time of measuring retention. The longer the time between original learning and the measurement of retention, the less the amount retained. The increase in memory error, as indicated by the curves, is very rapid at first, followed by a gradual decrease in rapidity. Even when retention is measured immediately after learning, there is some loss. Whiteley and McGeoch[1] found that the curve of retention

[1] Whiteley, P. L., and J. A. McGeoch, The curve of retention for poetry, *J. Educ. Psychol.*, 1928, 19, 471–479.

for poetry declines abruptly from immediate recall to recall after 30 days, very gradually from 30 to 100 days and a relatively insignificant amount from 30 to 90 days after learning. For extremely short intervals, Brown[1] has shown that recitation 16 minutes after learning is but slightly inferior to recitation after an interval of 8 minutes. The amount forgotten at any specified period is difficult to determine, although general tendencies may be noted from the curves presented.

Whatever the amount forgotten for any interval, a large percentage of material is lost in a relatively short period after learning. Perhaps, of all the material learned, that part only which remains after the initial forgetting process has ceased should be considered. This subject matter is the only material which has actually become a part of the pupil's thinking, unless care has been taken to provide for frequent reviews. Distributions of relearning should be arranged in order to conform to the nature of the curve. Frequent reviews immediately after learning tend to lessen the initial abruptness of the curve. After the initial period of forgetting has ceased reviews may be distributed farther apart. Tsai[2] performed three experiments to test the validity of this principle in the field of advertising and found that "the results on the distribution of relearning of such materials after a partial degree of original learning stand strongly in favor of that mode of distribution with initial frequency followed by gradual increase in the length of time increase between subsequent trials."

2. **The Method of Measurement.**—The curve of retention is also influenced by the method of measurement. Individuals respond differently to each type of measurement, which is due primarily to their method of recording observations. Some individuals retain exact mental images of stimuli and, owing to the accuracy of their mental pictures and their ability to reproduce details, are often referred to as having photographic minds.

[1] Brown, Warner, Effects of interval on recall, *J. Exper. Psychol.*, 1924, 7, 469–478.

[2] Tsai, L. S., The relation of retention to the distribution of learning, *J. Exper. Psychol.*, 1927, 10, 30–39.

Others develop their own associations and methods of learning, and any deviations from their method of learning tend to inhibit their effectiveness in retention tests. Some do not form mental images nor stimulating associations and depend entirely upon outside stimuli as a basis of reproduction.

Figure 12 shows curves based upon the three major methods of measuring retention. These curves represent composite

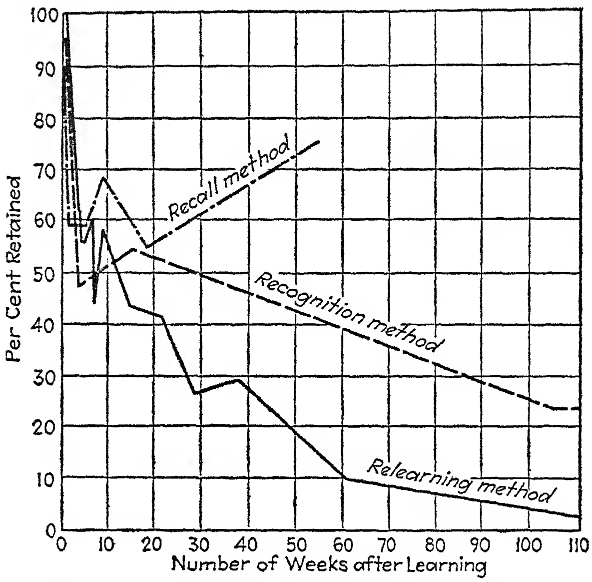


FIG. 12.—The curves of retention for both meaningless and meaningful materials as determined by the three major methods of measuring retention. (*From Robert A. Davis and C. C. Moore, Methods of measuring retention, J. Gen. Psychol.*, 1935.)

treatment of meaningless and meaningful materials interpreted on the basis of percentages. Although the curves are not altogether comparable, they indicate the influence of the method of measurement upon the amount retained. The relatively high value of the recall method is probably due to the completeness of mental pictures retained or to associations which the individual has himself developed.

The recognition method as commonly used does not measure the entire sequence of events as previously recorded and this

deviation from the order of learning tends to confuse the learner. The plausible answers to questions and statements provided by the method of recognition tend to lessen confidence and produce doubt and error, which accounts for the poorer retention value of this method. This condition is often observed in the courtroom when the witness, if allowed to tell his story in his own way, will give a straightforward report, but may become confused when cross-questioned.

The low retention value of the relearning method is probably due to the fact that in relearning the individual depends no longer upon his past knowledge but upon the immediate learning situation and considers the task from a new standpoint. Instead of using the associations already formed, he begins to form new associations. This tendency to attack the original learning situation from a new approach increases time and repetitions required for relearning.

3. **Kind of Material.**—Poetry, prose and observed material are retained much longer than nonsense syllables. Words[1] in the form of connected discourse are more easily retained than disconnected words or phrases, and pictures are more readily retained than their word equivalents. Abstract words and numbers are elusive and quickly forgotten. Nonsense and meaningless materials do not permit the formation of meaningful associations. Materials which have meaning and significance make possible the formation of a number of cues and contexts which form the basis for correlating and integrating materials being studied. It is usually found that any associated environmental factor facilitates learning and increases retention. In material having contextual relations there are always extra associations such that the presence of one tends to arouse others. It is through this element of association that a context word used during study will facilitate learning and enhance the power of reproduction.

The experiments bearing upon the retention of motor and mental learning usually show a high degree of retention for

[1] PETERSON, H. A., On the influence of complexity and dissimilarity on memory, *Psychol. Rev. Monog.*, 1909, 12, No. 2.

motor skills as compared with verbal and informational habits. McGeoch[1] has summarized the findings of several experiments in the following statement:

(1) Acts of skill such as typewriting and ball tossing are retained over long periods of time with a loss, which while small, is larger than it has often been interpreted to be, and are relearned with a larger percentage of saving; (2) nonsense syllables are retained much less well than are acts of skill reviewed, being almost completely forgotten after intervals of time over which skilled acts are still relatively well retained; (3) materials such as paired association, prose, poetry and observed data are forgotten much less slowly than are nonsense syllables; and perhaps no more rapidly than are acts of skill; (4) certain phases of phenomenal memory show as high a degree of retention as the classical "skill" experiments have shown.

In his own studies McGeoch has shown that the comparative retention values for nonsense syllables and skill in threading mazes are dependent upon the type of material and the method of measurement.

Abstract subjects are quickly forgotten while many habits such as driving automobiles, typewriting and riding bicycles are retained over a long period. Several reasons have been proposed to explain the difference in retention of motor and mental habits. It is held that the individual who learns a motor task practices and drills a great deal more than the same individual who learns history or mathematics; thus it is thought that overlearning may be an important factor conditioning permanency of motor habits. In learning a motor task one is able to learn more completely because one can test one's understanding and knowledge of the task as one's learning progresses.

The individual, in learning a motor task, is also able to use a greater number of sense avenues and therefore form a larger number of associations than is possible in the case of abstract subjects where seeing and hearing may be the only avenues of reception. Motor learning involves both ideational and motor responses, whereas mental learning may be limited to ideational responses only. This difference in the quantity and character of responses used in learning may account for the greater reten-

[1] McGeoch, J. A., The comparative retention value of maze habits and nonsense syllables, *J. Exper. Psychol.*, 1929, 12, 392–414.

tion value of motor habits. So far no investigator has been able to separate completely the types of responses involved in the two major methods of learning. The ideational phase of motor learning is probably retained long after the motor skill in performing the act has been forgotten. McGeoch[1] has recently shown that, when ideational and motor habits are learned according to a uniform criterion, there is little difference between the two types in retention for either long or short intervals. Although not clearly differentiating between motor and mental learning, his study is a refinement over previous methods of investigation and suggests problems for further study.

4. **The Organization of Material.**—Organization implies that there will be many associations developed around a particular topic or unit in a course, and major and subsidiary points may be studied in their relation to each other so that when one idea is recalled closely related ideas are also revived. Laird[2] believes that a logical organization for presentation of materials operates for the benefit of retention, even though the recall itself is unorganized. He also shows that in addition to the importance of organization in immediate recall, the value of organization to retention increases with the interval in delayed recall. Pan[3] required students to learn words in various contextual situations and later recall them when the context was present and when it was absent. The results show that recall of material is very definitely influenced by the presence of any environmental factor which is associated with it. The manner in which material is organized has a decided effect upon meaningful materials, and even meaningless materials have positive increasing value in proportion to their length where there is possibility for continuity of thought.

[1] McGeoch, J. A., The comparative retention values of a maze habit, of nonsense syllables, and of rational learning, *J. Exper. Psychol.*, 1932, **15**, 662–679.

[2] Laird, D. A., H. Remmers and L. J. Peterson, An experimental study of the influences of organization of materials for memorizing upon its retention, *J. Exper. Psychol.*, 1923, **6**, 69–81.

[3] Pan, Shuh, Influence of context upon learning and recall, *J. Exper. Psychol.*, 1926, **9**, 468–491.

5. The Degree of Learning.—Among early studies on learning there was a practice of developing the learner's ability to the extent of making one errorless reproduction of material studied. Practice beyond that point was considered overlearning, while various degrees of ability to reproduce material learned to the point of one errorless reproduction were termed underlearning. Ebbinghaus observed that as the number of readings increased there was a tendency for the material to become more thoroughly entrenched in the mind of the learner. He believed that the degree of learning bore a very definite relationship to the degree of subsequent reproduction. For material he used nonsense syllables which were learned to different degrees of mastery; after a definite interval of time they were relearned to the point of their original status. He was thus able to determine resulting savings in work in relation to the number of repetitions required for complete reproduction after lapses of time. The difference between the number of repetitions required for original learning and relearning thus constituted the amount of saving. He found that the number of repetitions made in the original learning had a definite relationship to those necessary for relearning. In brief, a certain number of repetitions beyond that required for one errorless reproduction had a beneficial effect upon ability to relearn.

Krueger[1] sought to determine the relationship between various degrees of overlearning and retention after varying intervals of time. He wished to know whether 50 per cent of overlearning increased the amount retained by 50 per cent or by some other amount, and further whether the relation between the degree of learning and retention varied with the interval between learning and recall. If 50 per cent of overlearning increases retention by 50 per cent after a one-day interval, will this percentage increase or decrease with the length of the interval?

Krueger's results are given for two types of material. In one study his subjects were required to memorize such mate-

[1] Krueger, W. C. F., The effect of overlearning on retention, *J. Exper. Psychol.*, 1929, 12, 71–78.

rials as nonsense syllables and nouns. He also experimented with an act of skill, in which the subjects were required to master a finger maze. In his study with nonsense syllables and nouns it was shown that a certain degree of overlearning up to about 50 per cent was highly desirable from the standpoint of retention for intervals ranging from 2 to 28 days, and that the longer the interval, the greater the economy. Further increases of overlearning also proved to be economical for most intervals. As the degree of learning was increased from 150 to 200 per cent (or an addition of 33⅓ per cent), the corresponding increase in retention was usually less, but the proportion did not vary consistently with the length of the interval.

The degrees of learning in the second study[1] were 100 per cent learning and 50 and 100 per cent overlearning. By 100 per cent learning was meant the amount of attainment necessary to trace the correct path of the finger maze without error. By comparing the trials, time and number of errors made for 100 per cent learning with those for relearning, it was possible to obtain some definite results on the influence of overlearning on retention. The results obtained from this study were similar to those for nonsense syllables and nouns. As the degree of learning was increased from 100 to 150 per cent, there was always an increase in the retention scores for all intervals, and this proportional increase was always less than 50 per cent. As the degree of learning was increased from 150 to 200 per cent (or by an additional third), the corresponding increase in retention scores was usually more than a third, especially for the longer intervals. There was, however, no consistent relationship between the proportional increase in retention and length of interval. The results in general indicate that there is a limit to the efficiency of continued practice. That is, the increase from 100 to 200 per cent is usually less economical than 50 to 100 per cent overlearning.

[1] KRUEGER, W. C. F., Further studies in overlearning, *J. Exper. Psychol.*, 1930, **13**, 152–153.

LUH, C. W., The conditions of retention, *Psychol. Rev. Monog.*, 1923, **31**, No. 142.

These studies indicate that at least 50 per cent overlearning is highly economical for materials involving ideas and skill. If 50 per cent overlearning is desirable, it does not necessarily follow, however, that an additional 50 per cent would result in proportional increase in retention. The intervals between learning and relearning in the studies reported are not sufficiently long to justify definite conclusions for materials which are relearned after long lapses of time. It may be expected that overlearning is more important for materials which are to be relearned, reproduced or recognized at a remote time than for those which are measured in relatively short periods. Some overlearning is necessary in any subject and study should be extended beyond the point of mere understanding. It is too often believed that, once a principle is understood, further study is unnecessary. Material learned to such a degree does not insure accuracy and speed in discussion and in answering questions on examinations. It is also highly desirable that much time be spent in evaluating and integrating that which is being studied. The practice of digesting materials that have been studied, although not objectively manifested, is an important phase of overlearning and is highly important for retention.

6. The Distribution of Effort and Method of Learning.—In general, retention will be much better if study is distributed rather than concentrated. With distributed learning more associations are formed which facilitate revival of previous experiences. Distributed learning provides for extensive as well as intensive effort, and permits the learner to evaluate and organize materials in terms of his own thinking process. Learning by the whole method insures greater permanency than learning by the part method. In learning by the whole method there is continuity of thought that increases interest and stimulates desire for retention. The whole method gives assurance that more associations will be formed and that there will be a basis for seeing various bits of information in their relation to each other and to the whole.

7. Confidence and Intention to Retain.—The individual's faith in his ability to retain that which is being learned implies

confidence. It is enhanced by success and dwarfed by failure. Pupils tend to like tasks which are attended by success and to dislike those which are accompanied by failure. Lund[1] has shown that retention, as measured by the method of recognition, is attended by various degrees of confidence, and that the degree of correctness has a tendency to vary according to the degree of confidence present. Students indicated in a test after "yes" and "no" statements their confidence by the terms "quite certain," "fairly certain," "think so" or "don't know." These responses varied according to the degree of feeling of familiarity experienced while taking the test. The terms were correlated with correct and incorrect responses. Lund states:

> The degree of certainty which a present situation has with a previous situation and, therefore, the degree of similarity which present perceptional and associative reactions have with previous ones, determines the degree of confidence. The ability of a present event to arouse revelations which carry with them the sense of having been experienced before, the ease with which present stimuli redintegrate a familiar pattern response, and the combined effect of elementary reactions afforded by a situation or the nature of the perceptional reactions to them as a group are the determining factors of the criteria of confidence.

In so far as the student's knowledge is hazy, indefinite and superficial, confidence in retention as shown by recognition tests will be slight or even lacking. Confidence is dependent upon the degree to which students thoroughly prepare their work and study with definite purposes.

Brown and Lewin[2] had the same students work with two learning situations which were equal in difficulty and similar in content. In one case examiners told the students that the learning situation was inconsequential from the standpoint of judging their abilities and that they would not be held responsible for the record they might make. In the other case they were told that the learning situation was of extraordinary importance and that they would be critically judged upon

[1] Lund, F. H., The criteria of confidence, *Amer. J. Psychol.*, 1926, 37, 372–381.
[2] Personal interview.

the results that they might achieve. These students were tested at definite intervals for retention of content of the two situations and the relative retention values were compared. When the tests were not emphasized for their significance and importance, the curve of forgetting showed a marked decrease in the amount remembered with the lapse of time. In the case of the situation which was emphasized as of unusual importance the curve of forgetting was slow and gradual.

The lesson which this experiment enforces is that in teaching it is of primary importance that significant materials in a course be given a high degree of reality in the minds of pupils. Parts worthy of remembrance should be pointed out and emphasized as the work progresses. Learning with the intention to retain has a tendency to induce greater emphasis upon the establishment of meaningful associations while learning is in progress. It is not only effective in immediate retention but becomes increasingly more proficient as the interval is lengthened.

8. Agreeable and Disagreeable Material.—Several investigators have tested the Freudian theory that the unpleasant is more readily forgotten than the pleasant. Both Anderson[1] and Gordon[2] studied the relation of unpleasant and pleasant odors to recall, and found that there is not sufficient difference between the reactions to justify a conclusion in favor of either. Thompson[3] states that we forget the unpleasant more readily than the pleasant, while Myers[4] believes that one tends to recall that which is liked best more readily than that which is liked least.

Wohlgemuth[5] studied the recall of pleasant and unpleasant experiences of several hundred school children ranging in age

[1] ANDERSON, A. C., and F. J. BOLTON, Inhibition of unpleasant, *J. Abn. & Soc. Psychol.*, 1925–1926, **20**, 300–302.

[2] GORDON, KATE, Recollection of pleasant and unpleasant odors, *J. Exper. Psychol.*, 1925, **8**, 226–239.

[3] THOMPSON, R. H., An experimental study of memory as influenced by feeling tone, *J. Exper. Psychol.*, 1930, **13**, 462–468.

[4] MYERS, G. C., Affective factors in recall, *J. Phil. Psychol. & Scient. Meth.*, 1915, **12**, 85–92.

[5] WOHLGEMUTH, A., Influence of feeling on memory, *Brit. J. Psychol.*, 1923, **15**, 405–416.

from eleven to sixteen years. At his direction these children listed all the pleasant and unpleasant experiences they had had during a holiday period. After a period of two weeks, and with no previous warning, the same children were asked again to record all of the pleasant and unpleasant experiences they had had during the holiday period. The experiences so collected from both testings were compositely treated with the following results:

Both schools together; 687 children (age 11 to 16)		
1. Pleasant experiences recorded in first paper........	6,735	
2. Pleasant experiences forgotten in second paper.....	2,700	40.1%
3. Unpleasant experiences recorded in first paper......	3,491	
4. Unpleasant experiences forgotten in second paper..	1,406	39.8%
The percentage worked out for each child separately gave		
1. An average for pleasant experiences forgotten............		38.2
2. An average for unpleasant experiences forgotten..........		35.3
3. A mean for pleasant experiences forgotten...............		37.5
4. A mean for unpleasant experiences forgotten.............		33.3
The number of children		
1. Who forgot a larger percentage of pleasant experiences....		345
2. Who forgot a larger percentage of unpleasant experiences..		280
3. Who forgot an equal percentage of experiences...........		62

The figures indicate a greater tendency to forget pleasant experiences, but the difference is so small it is safe to conclude, as did Wohlgemuth, that there is little difference between pleasantness and unpleasantness in their influence upon memory. Dudycha[1] found that, for the most part, adolescents have memories of their preschool experiences which deal with situations and incidents connected with some emotion. The emotion which was remembered most often was fear, which included 39.5 per cent of the 200 memories studied, and of this group fear of animals and fear of punishment headed the list. Joy appeared to be second, but it included only 24 per cent of the memories of the list. The third group comprised anger. These results indicate that whether pleasant or unpleasant

[1] Dudycha, George J. and Martha M., Adolescents' memories of preschool experiences, *Ped. Sem.*, 1933, **42**, 468–480.

experiences are more often recalled is dependent upon the type and degree of emotion aroused by the experience.

The studies reviewed above are chiefly subjective and the techniques employed may be questioned. However, there are some investigations which, although not conclusive in their findings, have used objective methods and have indicated trends which hold promise for further study. One of the most comprehensive of these studies is that by Smith,[1] who studied the relation between memory value for words and their emotional significance as revealed by objective tests. His method consisted in measuring quantitatively the amount of affective tone aroused in individuals by certain words and also the ease with which these words are retained. In attaining this objective three different measures for estimating the degree of affective tone evoked by words were employed: (1) psychogalvanic reflex, (2) reaction tone measured in fifths of words and (3) Jung's reproduction tests. Although there were minor variations in the results obtained from these tests, it is noteworthy that all of them point toward the same conclusion. It was found that such words as love and money were positive and well remembered, while words such as insult and afraid were negative and repressed.

Smith interprets his data as showing that, as far as affected tone is measured by the galvanic reflex, it may be produced in either of two opposite directions. The fact that a particular word evokes a well-marked affected tone may lead to its being quickly forgotten, showing that affected tone as measured by the galvanic reflex may be regarded as of two kinds—one which facilitates and the other which inhibits remembrance of the word which it accompanies.

An investigation by Jones[2] tends to confirm this idea. He shows that an increased emotional tensity may affect learning and retention either favorably or unfavorably, depending upon whether the emotion is positive or negative. Although these

[1] Smith, W. W., Experiments on memory and affected tone, *Brit. J. Psychol.*, 1921, 11, 225–235.

[2] Jones, H. E., Emotional factors in learning, *Gen. Psychol.*, 1929, 2, 263–272.

experiments do not yield conclusions definite enough for application, they raise the question and suggest the need for further research. It is probable that the unpleasant is as readily remembered as the pleasant but that there is less tendency to mention the unpleasant.

D. Retention in School Subjects

The teacher is interested not only in how much information and knowledge are retained for any subject, but in the factors which contribute toward such retention.

1. Retention in High School and College.—Eikenberry[1] studied the permanence of learning for several subjects studied in high school but not continued in college. As subjects he used members of senior classes who were taking educational psychology in Rutgers University and New Jersey College for Women. These students were given a series of standardized tests in Latin, history, geometry, physics and chemistry. Since college seniors represent a highly selected group, their scores were compared only with the norms of the upper half of high-school pupils. Eikenberry's results show that, when measured by these tests, retention of subject matter studied in high school but not continued in college is highest in American history and second in ancient history, with geometry, Latin, chemistry and physics following in the order named. He attributes the high degree of retention of United States history, ancient history and Latin to incidental learning because closely related subjects taken by these students in college aid in keeping the materials of high school alive. Likewise the lower retention of the other subjects may be explained by the fact that students have little opportunity to use or review these subjects after finishing high school.

Greene[2] studied the retention of information acquired in three college courses. As a basis for his study he used beginning

[1] Eikenberry, D. H., Permanence of high school learning, *J. Educ. Psychol.*, 1923, 14, 463–482.

[2] Greene, E. B., The retention of information learned in college courses, *J. Educ. Res.*, 1931, 24, 262–273.

courses in zoology and psychology and an advanced course in physiological chemistry, and compared the results of examinations obtained in these courses in June with those from the same examinations in October. There were 1,062 students who took part in the study, divided as follows: zoology, 407; psychology, 525; and physiological chemistry, 130. The findings show that these students lost, between June and the

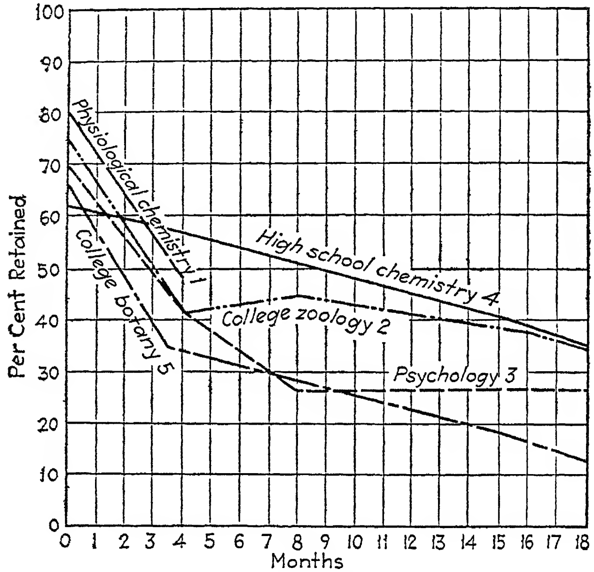


FIG. 13.—These curves represent the percentage of subject matter known at the end of courses as measured by objective tests and at definite intervals after that time. (*Curves* 1, 2 *and* 3 *after Greene,* 1931; *curve* 4 *after Powers,* 1924; *curve* 5 *after Johnson,* 1930.)

following October, about half of the information learned. Myers[1] asked 107 girls, who had completed one year in the Brooklyn Training school for Teachers and a course in United States history one year before in high school, to state during a class period one important fact of American history which they could associate with 50 selected names. His findings show that only 45 per cent of the answers were correctly given; 23 per cent were only partially correct; 15 per cent were

[1] MYERS, G. C., Delayed recall in American history, *J. Educ. Psychol.*, 1917, **8**, 275–283.

wholly wrong; and 17 per cent were not attempted. The efficiency for the whole test was only 58.5 per cent.

These investigations forcefully show that a large percentage of that which is learned in high school and college is quickly forgotten. It seems safe to estimate that not over 50 per cent of that which is learned is retained after a one-year period. Although the largest amount of forgetting may be expected to occur during the first year, it may be assumed that retention curves for school subjects will approximate those for meaningful laboratory materials.

2. The Effect of Summer Vacation.—Recent investigators have tested ability in various school subjects in the spring and fall by duplicate forms of standardized tests. The loss or gain produced by summer vacation may thus be determined by the difference between the averages of the two sets of scores.

Brueckner and Distad[1] studied the effect of summer vacation upon reading ability of first-grade children and found a significant correlation between scores made on standardized tests in June and September. Bruene[2] found that summer vacation had a decidedly detrimental effect upon arithmetical computation, which showed a total loss of six school months. In arithmetical reasoning, however, the loss was almost negligible. Summer vacation had a favorable effect upon reading ability and produced an unfavorable effect upon language usage, spelling, history and literature. These findings agree with those of Patterson,[3] who found that summer vacation was detrimental to arithmetic in all grades between 4 and 8, but did not perceptibly affect reading ability.

Objective studies clearly indicate that in some subjects there may be expected a marked decrease in efficiency as a result of summer vacation, while in others there may be some

[1] Brueckner, L. J., and H. W. Distad, The effect of summer vacation on the reading ability of first-grade children, *Elem. School J.* 1923–1924, 24, 698–707.

[2] Bruene, Elizabeth, The effect of summer vacation on the achievement of pupils in the 4th, 5th, and 6th grades, *J. Educ. Res.*, 1928, 18, 309–314.

[3] Patterson, M. V. W., The effect of summer vacation on mental ability of children and their retention of arithmetic and reading, *Educ.*, 1925–1926, 46, 222–228.

improvement. Subjects primarily influenced by the formal work of the school and not likely to be practiced during vacation usually show a loss in efficiency. Since the fundamentals of arithmetic are least likely to be used during vacation, this subject invariably suffers the greatest loss. The slight improvement in reading may be due to the fact that vacation affords an opportunity for extensive practice and is more directly influenced by environment outside of the school. The same explanation may also be made for nature study and science since, through travel or intimate association with outdoor life, pupils may broaden their information in these fields during vacation. Spelling is more directly influenced by school environment, which explains the loss in this subject.

Although these studies show definite increase or decrease in efficiency during summer vacation, they do not analyze the reasons for gains or losses. It would be valuable to determine the activities of pupils during vacation which would cause the gains and losses found in different subjects. In spite of lack of information, the studies raise some important questions for the teacher and school. One of the first observations is that in some subjects the teacher cannot make any definite assumptions regarding the efficiency of her pupils at the beginning of the school year. Some teachers recognize this loss due to summer vacation and spend much time in reviewing the work covered the preceding year, while others launch immediately into new subjects or courses with the belief that pupils are prepared to go forward. Kirby,[1] who studied the effect of specific training in addition and division, found that in the spring it required about 30 minutes drill in addition to bring the group to the same level of efficiency it had attained the previous fall by 75 minutes of drill.

Morgan[2] studied the effectiveness of specific training in preventing loss due to summer vacation. His results show

[1] KIRBY, T. J., Practice in the case of school children, *Teach. Coll. Contrib. Educ.*, 1913, No. 58.

[2] MORGAN, L. D., How effective is specific training in preventing loss due to summer vacation? *J. Educ. Psychol.*, 1929, **20**, 466–471.

that a group of sixth-grade children who received special training for two weeks before the end of school made a much better showing at the beginning of the next school year than a parallel group not receiving such training. Whether special training is given before or after vacation, the teacher should spend some time at the beginning of the school year in reviewing the previous work in order to check the pupil's background and to prepare him for the new work.

E. Some General Questions about Retention

1. The Memory Span and Retentive Ability.—The memory span refers to the number of symbols or words that can be reproduced immediately after hearing them. In the Stanford Revision test there is an exercise in which the examiner calls various numbers of digits at a specified rate. The pupil is then required, when the list is completely read, to reproduce all the digits that can be remembered. The number of digits that can be recalled thus constitutes the memory span. Mitchell[1] shows that there is a wide variation in the memory span of individuals of the same age. A person of poor ability may have a memory span of 3, 2 or 1, while exceptional individuals may be able to reproduce 10, 11, 12 or even greater numbers of discrete impressions. Young[2] in a study of audito-vocal digit spans for children from four to ten years concludes that the average digit span for children of four and five years is 4 digits; for six- and seven-year-old children, 5 digits; for eight-, nine- and ten-year-old children, approximately 6 digits.

Dietze[3] shows that memory for facts of an article improves through adolescence, after which there seems to be only slight improvement. Lyon[4] shows that the number of retained

[1] Mitchell, David, Variability in memory span, *J. Educ. Psychol.*, 1919, **10**, 445–457.

[2] Young, Mary H., A comparative study of audito-vocal digit spans, *Psychol. Clin.*, 1928–1929, **17**, 170–183.

[3] Dietze, A. G., and G. E. Jones, Factual memory of secondary school pupils for a short article which they read a single time, *J. Educ. Psychol.*, 1931, **22**, 586–598, 667–676.

[4] Lyon, D. O., Relation of quickness of learning to retentiveness, *Arch. Psychol.*, 1915–1917, **5**, No. 34.

members of any series increases from age level to age level, and that children in higher chronological ages show definitely greater ability in reproducing stories. Guillet[1] states that the adult retains about two and one-half times as much as the child when measured by the relearning method. In general the ability to retain increases with age regardless of kind of material or method of measurement, and the development follows the same trend as other mental functions.

The question of good and poor memories has usually centered around the problem as to whether there is a general memory or a number of specific abilities. Even when phases of the same mental function are correlated, the relationship is not always close. For example, the relationship between immediate and delayed recall is positive though not usually high. A pupil may have a good memory for athletic events and show poor ability in the recall of facts in English literature. Whether the memory be good or poor for certain situations depends a great deal upon interest and information. Materials in which we are intensely interested are easily remembered while those in which we have little concern are difficult to recall. For practical purposes at least, it does not appear that there is sufficient evidence to justify the belief in a general memory ability.

2. Intelligence and Sex.—Memory is a functional part of general intelligence and is measured either directly or indirectly by all intelligence tests. Memory, when correlated with scores on general intelligence tests, usually shows a positive, though not close, relationship. In general those who have the highest intelligence also have the highest retentive ability. There are extreme cases, of course, where good memory is accompanied by either very high or low intelligence. Differences between bright and dull children are more pronounced in some kinds of materials than in others. Bright pupils may be expected to demonstrate greater superiority in the case of logical memory, although the two types may not be expected to differ markedly in rote memory. Bright pupils surpass

[1] Guillet, C., Retentiveness in child and adult, *Amer. J. Psychol.*, 1909, 20, 318–352.

dull pupils to a greater extent in meaningful materials, especially where there is opportunity to establish logical relations. Because of their better adaptability, bright pupils are able to see relationships, to generalize and to use better methods of study. Bright pupils not only learn more readily, but retain a much higher percentage of what they learn.

The retentive ability of both sexes is practically equal. However, there are some aspects of retention where noticeable differences between sexes have been found. Women are superior to men to a perceptible degree in both immediate and delayed recall, but women tend to make more routine errors in reporting an observation than men. The average retentive ability for words and syllables is slightly higher for girls, while boys do better in forms and logical organization. Girls appear to have a slight advantage when retention is measured by the ability to reproduce, while in other methods of measurement boys approximate, if not excel, girls. Myers[1] found that the greatest difference between the sexes was in the ratio of recognition to recall. The average efficiency for boys is about three times greater for recognition than for recall, while the ratio for girls is about two times greater for recognition than for recall. When retention is measured by the method of recall, girls are likely to be superior, but with other measures of retention there is no significant difference, with the possible qualification that boys tend to approximate the ability of girls. Differences which are found may be attributed to differences in training and environment.

3. **Memory Training.**—Memory is definitely influenced by heredity but may be improved in its expression by training. Limits of improvement are established by innate inheritance. Good retention is influenced by all of the factors discussed in the preceding sections. Retention is weakened by disuse and frequent repetitions are necessary to keep alive associations previously formed. Probably the most important means for improving memory is that of organizing subject matter so that there will be a number of pivotal

[1] Myers, G. C., A comparative study of recognition and recall, *Psychol. Rev.*, 1914, 21, 442–456.

points around which may be grouped a large number of contributing associations. Good retention is dependent upon the meaning of materials studied and the number of associations developed. The teacher may guide the pupil by organizing subject matter in such a way that there will be proper sequences and orderly arrangement of outlines so that he is able to determine pertinent relationships.

The popular systems which have been devised to aid the public in the improvement of memory have usually failed to achieve their objective. These systems usually furnish associations which, when connected with the material to be learned, afford extra meanings and consequently aid retention. In so far as they furnish extra incentives for improvement and additional associations, they are of some value. They are poor in that the extra devices do not in themselves possess meaning, and they thus place memorization upon a rote basis.

F. Summary

Once learning has been produced there is the problem of making it permanent. Learning becomes permanent only when fortified against influences which produce forgetting.

Retention may be measured by the methods of relearning, recall and recognition, and each of these methods has its particular techniques, which measure different phases of the same process. The relearning method is most applicable for experimental purposes, while the methods of recall and recognition are most useful as measures of school achievement.

The curve of retention is a graphic representation of the amount retained for varying lengths of time. The amount retained is influenced by the following factors: (1) the time interval; (2) the method of measurement; (3) the kind of material; (4) the organization of material; (5) the degree of learning; (6) the distribution of effort and the method of learning; (7) confidence and intention to retain; and (8) agreeableness and disagreeableness of materials.

The longer the interval between learning and the measurement of retention, the less the amount retained. The curve

of retention shows that a large percentage of that which is learned is quickly forgotten, while that which remains after the period of initial forgetting is retained at a more stable rate. The method of recall appears to have the highest retentive value and is followed in merit by the methods of recognition and relearning. Retention is much better for meaningful than meaningless materials, and motor skills tend to be retained longer than words and ideas.

Retention is enhanced by orderly arrangement of materials during learning. Overlearning is essential in all subjects and may consist in continued drill or assimilation of that which has been studied. In distributed learning there is opportunity to form useful associations. The chief advantage of the whole method of learning is that it provides opportunity for the formation of many associations. Confidence and intention to retain imply an active attitude toward work with emphasis upon pertinent relationships and the minimizing of distracting influences. Although it is controversial whether agreeable or disagreeable materials are better remembered, pleasant materials are positive and produce attitudes conducive to learning and retaining.

The curve of retention for school subjects is similar to that for meaningful laboratory materials. It shows that a large part of that which is learned is forgotten during the first year. Summer vacation produces improvement in a few subjects, but in the majority of subjects its influence is detrimental. Pupils should be fortified against such loss by reviews, either during the latter part of the school term or at the beginning of the school year.

The memory span varies widely in different individuals and shows a continuous development through adolescence. The bright pupil not only learns more readily but retains a greater amount of that which he learns. Sex differences in retentive ability are slight and are influenced by types of materials, methods of measurement and environment. The program which provides opportunity for the establishment of many associations is likely to produce the largest amount of retention.

CHAPTER X

TRANSFERENCE AND INTERFERENCE IN LEARNING

Transference of learning has been an interesting topic in every period of educational history. The doctrine of formal discipline was first proposed by Plato who believed that such subjects as arithmetic, music and astronomy should be studied for the purpose of improving the power of speculative thinking, rather than for their practical value. The Romans believed in practical education and specialized training. During the seventeenth century Locke[1] proposed the doctrine of formal discipline as the chief aim of education. He believed that mental development could best be achieved by performing difficult tasks and he advocated the doctrine of specific training for the development of physical ability, and for mental ability the doctrine of formal discipline. Latin and Greek were introduced into the curriculum for the purpose of disciplining the mind. Locke thus incorporated the cultural theory of the Greeks and the practical points of view of the Romans.

The majority report of the "Committee of Ten"[2] in 1892 approved formal discipline as an aim of education, although the minority report of the committee indicated an unfavorable attitude. The minority report was significant because it showed that school men were no longer united in behalf of the doctrine of formal discipline. About this time James[3] directed attention to the wasteful process of indirect training, and the doctrine of formal discipline rapidly lost its popularity in favor of specific training.

Transfer of training in its early conception was essentially the same as formal discipline. It proposed the theory that, in

[1] HODGE, F. A., *John Locke and Formal Discipline*, Doctor's Thesis, Univ. of Virginia, 1911.

[2] Report of the "Committee of Ten."

[3] JAMES, W., *Principles of Psychology*, New York, Longmans, Green, 1890.

order for the mind to develop and grow, it must be set to difficult tasks, assuming that the more difficult the task, the greater the disciplinary value. The theory further assumed that if an individual is proficient in reasoning in one situation he will be equally proficient in others, and proposed that proficiency in many fields of subject matter insured proficiency in any specialty.

Transfer of training as it is viewed today is a process of acquiring ideas, information or skills in one situation and applying this knowledge to other situations, whether similar or different. Specifically, it is the utilization of previously gained knowledge in a practical situation; generally, it is the utilization and application of education in the solution of life problems. Transfer of training is one of the three major problems of educational psychology. Educational psychology is concerned primarily with the processes of acquiring, retaining and applying knowledge. Transfer of training is essentially a process of application.

The early method of studying transfer of training was to test an individual or group in a certain function A, train in another function B, and then retest in the function A, in order to determine the improvement made in A as a result of training in B. Since the introduction of a control group in transfer study by Winch[1] in 1908, most subsequent investigators have used at least two groups for experimentation. Both groups are measured in function A, but only one group is given the training B. The gain made by the control group (which has not had the training) is compared with that made by the experimental group so that the influence of specific training may be determined. Experimental techniques have further been refined by the use of two or more equivalent groups and an additional group which takes no training. There are also variations of these techniques including the rotation procedure, in which experimental factors and groups are so rotated that each group is subjected to the same experimental factors in

[1] WINCH, W. H., The transfer of improvement in memory in school children, *Brit. J. Psychol.*, 1908, 2, 284–293.

a definite order. The descriptive method is employed to study the relationship of abilities or functions by the correlation device.

A. Experimental Study of Transference in Learning

Objective study of transfer began about 1890, when several investigations were reported. The years between 1900 and 1915 represented an active period in the development of experimental investigations and with increased interest in the problem there was also a refinement of investigational procedures. Since 1915 there has been constant interest in transfer and improvement in methods of investigation, although other problems in educational psychology have been relatively more impelling.

1. Transference in Motor Processes. *a. Cross-education.*—It has long been recognized that practice with one part of the body in performing a skilled act increases the ability of the bilaterally symmetrical part in performing the same act. Practice with one hand transfers to the other; practice with one foot transfers to the other foot; while practice with one eye transfers to the other eye in the same skill. Transfer of this type is termed cross-education.

Davis[1] found that practice in hitting a target with a fencing foil in the right hand improved the left hand 75 per cent. He also found that strength developed in the right arm by swinging dumbbells, pressing a dynamometer and pulling an ergograph tended to increase the skill of the left arm 70 per cent. Bray,[2] using mirror drawing, found that there was not only transfer from the right to the left hand but also from the right hand to the left foot. Cook,[3] after having 10 subjects practice with the right hand 100 trials in mirror-tracing a star-shaped maze, tested the left hand, right foot and left foot. He found

[1] Davis, W. W., Researches in cross education, *Studies from the Yale Psychol. Lab.*, 1898, **6**, 6–50; Second series, 1900, **8**, 64–108.

[2] Bray, C. W., Transfer of learning, *J. Exper. Psychol.*, 1928, **11**, 443–467.

[3] Cook, T. W., Studies in cross-education: mirror tracing the star-shaped maze I and II, *J. Exper. Psychol.*, 1933, **16**, 144–160, 679–699.

a large amount of transfer to all muscular groups tested for 10, 20, 30 and 100 practice trials. Transfer was greatest to the muscle group opposite and symmetrical, next to that on the same side and least to the group opposite and unsymmetrical to the practiced hand or foot. Munn[1] found that, when 50 subjects were given 50 trials with the left hand followed by 500 trials with the right hand on a task involving eye-hand coordination, a subsequent 50 trials with the left hand showed an average improvement of 61.14 per cent. A control group of equal ability showed an improvement of 28.5 per cent. The net amount of transfer due to practice with the right hand was 32.59 per cent. Munn thinks that the subjects had a tendency to formulate the problem during training and that this formulation of method transferred to practice with the left hand.

Cross-education studies do not deal with transfer of training proper, but an understanding of the more significant of these investigations should give a better idea of the experimental approach to the transfer problem.

b. Motor Skills.—The experiments reviewed on cross-education lead to a consideration of the evidence dealing with transfer of training in motor skills in which the transfer is not bilateral. Bair[2] in a study of transfer used four subjects and labeled six keys of a typewriter with different symbols. These symbols on flash cards were shown in chance order and the time taken to tap them out correctly was recorded. Although the symbols were changed with every series, each subject showed a decrease in time. Since there was a change in series with each practice, Bair concluded that there was a definite transfer effect. Webb,[3] who used the maze as a method of measuring transfer, studied 21 human subjects and 54 rats. The results of the savings in learning a second maze by human subjects were as follows:

[1] MUNN, N. L., Bilateral transfer of learning, *J. Exper. Psychol.*, 1932, **15**, 343–353.

[2] BAIR, J. H., Practice curve, *Psychol. Rev. Monog.*, 1902, **5**, No. 19.

[3] WEBB, L. W., Transfer of training and retroaction; a comparative study, *Psychol. Rev. Monog.*, 1917, **24**, No. 104.

Mazes	Trials	Errors	Time
A—D	51 98	94.58	88.73
A—B	67.86	86 64	67 18
A—C	19.74	20.20	29 18

Experiments dealing with cross-education and motor skills show that there are definite transfer effects. The marked transfer in cross-education studies is probably due to increased coordination between mind and muscle. The marked improvement usually obtained in motor skills and cross-education is probably due to the effects of specific and direct training.

2. Transference in Mental Processes.—*a. Memorization.*—James[1] experimented upon himself in order to determine the effect of training in learning one kind of poetry upon memorizing other kinds. In 8 days he memorized 158 lines of Victor Hugo's *Satyr*, which required a total of about 131 minutes. He then spent 20 minutes a day for 38 days in memorizing the first book of *Paradise Lost*. At the end of this time he again memorized 158 lines from Victor Hugo's *Satyr* and found that it took him 151½ minutes. James concluded that one's innate memory could not be improved by practice and that any improvement in memory was primarily due to acquisition of more efficient methods of recording facts. His conclusion dealt an important blow to the doctrine of formal discipline. Ebert and Meumann[2] wished to determine whether there was a general memory function or specific memories which could be developed by special practice; they concluded that much improvement was due to the effects of indirect training.

Sleight[3] pointed out that the number of subjects in the Ebert and Meumann experiments was so small that one

[1] James, *op. cit.*

[2] Ebert, E., and E. Meumann, Uber einige grundfragen der Psychologie der Ubungsphenomena un Bereeche der gedachtnisser, *Arch. gesamte Psychol.*, 1903, 4.

[3] Sleight, W. G., Memory and formal training, *Brit. J. Psychol.*, 1911, 4, 386–457.

individual was able to influence the average of the group, that no control group was used and there was no assurance that all of the end tests were of equal difficulty. In his own experiments Sleight gave his subjects a series of 10 tests to determine their initial memorizing ability. The groups were then equated on the basis of these tests and divided into practice and control groups. The practice group was divided into three sections, the first section practicing in memorizing poetry, the second tables and the third prose. At the end of three weeks' practice final tests were given and on the basis of his results Sleight concluded that there appeared to be no general improvement of memory as a result of practice and that there were several related and unrelated memory functions. He also concluded that the amount of transfer will be greater if the individual is aware of common elements, although common elements do not insure transfer.

Woodrow[1] believed that memorizing itself did not transfer but that such transfer as had been found was due to improvement in methods of memorizing. His method consisted in undirected drill in memorizing, which was performed by the practice group, and conscious guidance in the formulation of a technique of procedure, which was performed by the training group. As a basis of comparison there was also a third group which did not drill in memorizing. All of these groups were given initial and end tests, and in addition the practice group was required to drill in memorizing in a routine manner without discussion of techniques of procedure. In the case of the training group some practice was given in memorizing, but there was in addition a definite attempt to develop techniques of procedure. The devices used in developing ability in the training group included the following:

1. Learning by wholes.
2. Use of active-self-testing.
3. Use of rhythm and grouping.
4. Attention to meaning and the advantages of practicing.

[1] Woodrow, H., Effect of type of training upon transference, *J. Educ. Psychol.*, 1927, 18, 159–172.

5. Mental alertness and concentration.
6. Confidence in ability to memorize.
7. Use of secondary associations.

Woodrow's findings show that the group which was trained in the development of techniques of procedure was superior to the group which was trained in rote memorization. The facts indicate that the practice group sometimes improved to a greater extent and sometimes less than the control group. As Woodrow points out, however, in practically all of the end tests the difference between the improvement of the practice and control groups is so small as to be statistically unreliable. The improvement for the training group is, on the other hand, definitely greater than that of either the practice or control group.

It is difficult to conclude to what extent training in memorizing in one situation will transfer to similar or different situations. It is probable, however, that training in memorizing in a particular subject is more effective for that particular subject. It is also probable that when methods and techniques of memorizing have been consciously generalized they may effectively be used in many situations. Transfer is more directly influenced by methods and techniques than by the improvement of any innate memorizing ability.

b. Perception, Observation and Discrimination.—Whipple[1] studied improvement produced by practice in visual apprehension. In one experiment he tested the range of attention of several college students by means of a tachistoscope. He found very little practice effect and that which was noted he attributed to tricks of grouping and to habituation of experimental conditions. In another experiment on visual apprehension he exposed for 3 seconds groups of dots, pictures, drawings, nonsense syllables and stanzas of poetry; also 10 objects were exposed for 6 seconds. The findings of this experiment agreed with those of the first and indicated that practice effects were negligible when better adaptation and

[1] Whipple, G. M., The effect of practice upon the range of visual attention and visual apprehension, *J. Educ. Psychol.*, 1910, 1, 249–262.

assimilative devices were taken into account. The technique of Whipple was also used by Foster,[1] who studied the initial and final ability of individuals to "represent themselves in image impressions recently given in sensation." He also wished to determine the processes involved in observation and recall. His results indicated that training had little effect in making his subjects better observers and memorizers. He pointed out, however, that the experiments were made with adults who were trained in observation and that with children the results might have been different.

Dallenbach,[2] in order to obviate the difficulties suggested by Foster, extended these experiments to include both normal and feeble-minded children. Two studies were reported, the first dealing with normal children and the second with feeble-minded children. For 17 weeks normal second-grade children were given daily 10-minute exercises in rapid observation and reproduction of letters, digits, words and geometrical figures. His study indicated that practice produced a permanent change in several mental traits.

Thorndike and Woodworth[3] studied the influence of special training in the estimation of magnitudes upon the ability to estimate magnitudes of the same general type, and the influence of training in observing words containing certain combinations of letters upon the observation of words containing certain other letters. They concluded from the first part of the experiment that there was more improvement in ability to estimate areas similar to the practice material than in ability to estimate dissimilar areas. They concluded:[4]

[1] FOSTER, W. S., The effect of practice upon visualizing and upon the reproduction of visual impressions, *J. Educ. Psychol.*, 1911, **2**, 11–21.

[2] DALLENBACH, K. M., The effect of practice upon visual apprehension in school children, *J. Educ. Psychol.*, 1914, **5**, 321–334, 387–404.

DALLENBACH, K. M., The effect of practice upon visual apprehension in feeble-minded, *J. Educ. Psychol.*, 1919, **10**, 61–82.

[3] THORNDIKE, E. L., and R. S. WOODWORTH, The influence of improvement in one mental function upon the efficiency of other functions, *Psychol. Rev.* 1901, **8**, 247–261, 384–395, 553–564.

[4] *Ibid.*, 250.

The very slight amount of variation in the nature of the data necessary to affect the efficiency of a function-group makes it fair to infer that no change in the data, however slight, is without effect on the function. The loss in efficiency of a function trained with certain data, as we pass to data more and more unlike the first, makes it fair to infer that there is always a point where the loss is complete.

The results from the second part of the experiment showed that there was an indirect effect from practice in canceling words with certain letters on canceling words with other letters. The direct training was, however, more effective than indirect training.

Coover and Angell[1] tested several subjects in the ability to discriminate shades of gray before and after a training period of 17 days in discriminating intensities of sound. In most cases there was marked improvement in the ability to discriminate shades of gray after practice in discriminating sounds. They concluded that improvement consisted "in the divesting the essential process of the unessential factors." Fracker[2] tested the transfer effects of practice in discriminating sounds to memory for poetry, shades of gray, order of tones, order of geometrical figures, order of numbers and extent of arm movement. Although he found spread of training, he pointed out some of its limitations. Improvement, according to him, is due largely to establishment of standards. He agrees with Thorndike that improvement in any particular function need not improve ability in functions commonly called by the same name. However, direct practice is always more effective than indirect practice.

The data obtained from a study of perception, observation and discrimination are less definite than those for memorization. There is some evidence to show that generalized training in observing and apprehending transfers to other situations, although improvement is slight. Thorndike's experiment provides the most positive evidence for the influence of specific

[1] Coover, J. E., and F. Angell, General practice effects of special exercise, *Amer. J. Psychol.*, 1907, **18**, 328–340.

[2] Fracker, G. C., On the transference of training in memory, *Psychol. Rev. Monog.*, 1908, **9**, No. 38.

mental training. It is in the processes of observation, perception and discrimination that we find the most direct effects of specific practice. In the foregoing experiments, however, there was little attempt to develop general powers of perception and observation so that there was possibility for the individual to become conscious of the need for generalization of training.

c. Reasoning and Problem Solving.—There are many experimental results which show the influence of generalization upon learning of the simpler kind, but few that reveal how one learns to generalize, to abstract common and essential elements and to revise one's concepts in the light of further knowledge.

Ruger[1] arranged mechanical puzzles so that one puzzle, when mastered, offered a clue to the puzzle which followed. He found that transfer is increased in the higher mental processes involving generalization, analysis, methods of attack, higher levels of attention and ideals of efficiency.

Gray[2] compared rate of performance, retention and amount of transfer resulting from two learning situations. Group I worked with material in which there was no apparent relationship, while Group II worked with material in which systematic relationships were possible and requisite for success. The transfer effects for Group I were 31.9 per cent as compared with 51 per cent for Group II. In all respects the performance of the group which worked with materials capable of systematic relationships and of applications of a generalized principle was superior to that of the group working with material in which there was little or no possibility for discovering relationships and applying generalized principles. The students who had discovered the advantages of applying a general principle to one situation, when faced with a new situation of a problematic nature, began immediately to search for a general scheme or design in the material to which they could relate the individual items for purpose of ready memorization and recall. Their plan was to learn quickly the

[1] Ruger, H. A., The psychology of efficiency, *Arch. Psychol.*, 1910, 2, No. 15.

[2] Gray, C. T., A comparison of two types of learning by means of a substitution test, *J. Educ. Psychol.*, 1918, 9, 143–158.

general scheme; later they used it as a means of finding the separate items.

An experiment by Peterson[1] was of a somewhat different nature. Instead of determining the aid rendered by the ability to discover and apply general principles, he attempted to study the process by which one abstracts common and significant elements in a situation and develops and applies generalizations to new problems of a similar nature. His investigation was a study of the mental processes used in the solution of certain novel problems and the application of these experiences to the solution of similar problems. He devised a number of mathematical games so arranged that succeeding problems showed increasing complexity, yet involved more general statements of the solutions already made. Peterson believes that in solving such problems all forms of mental processes from simple perception to difficult abstractions and generalizations are involved. The results show that by far the greater amount of transfer occurred through the medium of concepts, general principles, attitudes and methods of attack.

There is evidence that experimentation in the memorizing of nonsense materials, of motor skills or even of meaningful materials does not necessarily reveal principles that are valid for the higher learning processes, such as the making of generalizations and the utilization of these in the solution of new problems. The ability to generalize is of such superior value in difficult learning situations that there is need for further investigation of its nature and the means for its improvement.

3. Transference of Methods and Techniques.—Although most experiments dealing with transfer in motor and mental processes have indicated the effects of techniques and methods, few have been specifically planned to test their effectiveness. Johnson[2] wished to determine whether pupils could more effectively prove theorems in geometry when they were given

[1] Peterson, J. C., The higher mental processes in learning, *Psychol. Rev. Monog.*, 1920, 28, No. 129.

[2] Johnson, E. P., Teaching pupils the conscious use of the techniques of thinking, *Math. Teach.*, 1924, 17, 191–201.

definite training in logical thinking. She also wished to determine whether pupils could apply techniques so learned to situations other than geometry. Using both experimental and control groups, she required the experimental group to practice in the solution of everyday problems according to Dewey's five steps in logical thinking, and to apply these steps to the solution of geometry problems. Both reading and reasoning tests were used as a basis of measuring improvement. Her findings show that training in the conscious use of logical reasoning not only produced improvement in geometry, but that pupils were able to use the technique in the solution of problems in other situations.

Meredith[1] also wished to determine the influence of training in the definition of scientific words upon the ability to define words used in everyday life. Three equivalent groups formed the basis for the study. Group A represented the control group, Group B the practice group and Group C the training group. With Group B the training given in the definition of scientific words was largely of a routine nature, while in Group C, in addition to drill in definition, there was critical analysis of the features of a definition. This analysis and evaluation of words included criteria for careful definition. Group C not only excelled in defining scientific words, but transferred this ability in defining words of everyday life.

The results of these and other experiments, designed to test the effectiveness of training in the techniques of learning and studying, are definite in showing that, when pupils are taught the conscious use of techniques of learning and formulating plans of procedure, this training will transfer to many situations. One of the most important functions of the school is to teach techniques of learning that may be applied to many subjects and learning situations.

4. Transference of Ideals and Attitudes.—Squires, under the supervision of Bagley,[2] conducted an experiment to deter-

[1] Meredith, G., Consciousness of method as a means of transfer of training, *Forum Educ.*, 1927, 5, 37–45.

[2] Bagley, W. C., *The Educative Process*, New York, Macmillan, 1919.

mine whether the habit of producing neat papers in arithmetic would transfer to other subjects. Bagley stated that the results were conspicuous in showing that habits of neatness in arithmetic did not transfer to improvement in language and spelling papers although the improvement in arithmetic was striking. He concluded that it was only when neatness was made a conscious ideal that it would transfer to other situations. This point of view was tested by Ruediger,[1] who wished to determine whether the ideal of neatness, developed in connection with one subject, would function in the case of other subjects. In addition to training pupils in neatness in written work, teachers emphasized the importance of neatness in dress and in the home. Ruediger's results showed that, when neatness is developed as an ideal, it will transfer not only to other subjects, but that it will function in one's personal and social life.

Dorsey and Hopkins[2] determined variations in the amount of transfer influenced by readiness to act as developed by suggestions at the time of performance. The method consisted in testing two groups of equal ability, suggesting to one group the use of material learned in a previous situation in answering questions and saying nothing to the other group about such use. Although these investigators conceded that transfer may be influenced by several factors, the attitude or motor set built up by suggestion is the most important influence in transfer of the study. The study indicated the need for making pupils conscious of elements in the present situation that can be transferred to other situations. It also suggested that pupils should be trained in the habit of attacking new problems in the light of previous experiences.

5. Transference in School Subjects.—It was to be expected that investigators, after having established results by studying transfer in various motor and mental processes,

[1] RUEDIGER, W. C., Indirect improvement of mental functions through ideals, *Educ. Rev.*, 1908, **36**, 363–371.

[2] DORSEY, M. F., and L. T. HOPKINS, The influence of attitudes upon transfer, *J. Educ. Psychol.*, 1930, **21**, 410–417.

would direct attention to the transfer of school subjects in which there is better basis for determining the significance of transfer in education. Investigations have been conducted in various fields of subject matter, the most fertile of these in the elementary school being arithmetic and in the secondary school Latin. There have also been investigations in grammar, spelling, modern foreign language, science and geometry.

a. Arithmetic.—Winch[1] studied the extent to which numerical accuracy would transfer to arithmetical reasoning. Of two groups of equal ability, one group was given practice in a series of numerical exercises familiar to the children while the other group was engaged in learning such subjects as history and geography. Later the two groups were compared on ability to perform tasks involving arithmetical reasoning. In one school there was no evidence of transfer but in the others the practiced group showed definite improvement in arithmetical reasoning. In a further study of the same problem he[2] found that, although practice produced marked improvement in accuracy of arithmetical computation, it did not tend to produce improvement in arithmetical reasoning.

Overman[3] studied the influence of instruction in three types of two-place addition upon the ability of pupils to perform related tasks in two- and three-place addition and subtraction. He also wished to determine the extent to which the amount of such transfer can be increased by helping pupils generalize and rationalize the process as well as their combined effects. The study was performed with 52 classes of second-grade pupils in three cities. The pupils were equated on several factors, divided into four groups and taught by four different methods. In method A pupils were taught to perform the process, but there was no attempt to teach generalization; in method B

[1] Winch, W. H., Accuracy in school children. Does improvement in numerical accuracy transfer? *J. Educ. Psychol.*, 1910, 1, 557–589.

[2] Winch, W. H., Further work on numerical accuracy in school children. Does improvement in numerical accuracy transfer? *J. Educ. Psychol.*, 1911, 2, 262–271.

[3] Overman, J. R., An experimental study of the effect of the method of instruction in transfer of training in arithmetic, *Elem. School J.*, 1930–1931, 31, 183–190.

pupils were aided in forming general methods of procedure which were emphasized; in method C reasons and underlying principles were discussed; and in method D general methods of procedure were indicated and underlying principles were emphasized. To determine whether the training that was given on three types of examples had any effect on the ability of pupils to perform the remaining types, percentages were computed of correct examples in the first and last tests for two of the untaught types of examples and for all untaught types combined. The percentages of transfer shown by the final tests for three types of examples and for all of the untaught types combined were as follows:

Type of Example	Percentage of Transfer
Addition of 4 two-place numbers	81 0
Addition of 3 two-place numbers	89.8
Addition of 1 three-place number and 1 one-place number	61.7
All untaught types	66.7

The findings of this study are summarized by Overman as follows:

(1) The effect of the instruction and practice given in certain specific types of examples was not confined to those types but spread to related types. For the group taught by the most favorable method the mean transfer was 72.4 per cent of complete transfer, and the range of transfer was from 50.6 per cent to 92.9 per cent on different types of examples. (2) On the examples which involved the placing of addends having different numbers of digits, method B (generalization) increased the transfer by 45.1 per cent, method C (rationalization) by 15.5 per cent and method D (generalization and rationalization) by 36.9 per cent.

It is not sufficient in arithmetic to teach only simple facts and processes; rather the pupil should be taught to generalize the process. Investigations in the field of arithmetic show that transfer may be slight or marked, and that the extent to which it takes place is largely dependent upon the method of teaching. The most important factor appears to be that of aiding pupils in generalizing and applying knowledge in studying either fundamental processes or other phases of arithmetic.

b. Latin.—Most investigators have been eager to test the claims of the formal discipline school which emphasized Latin as a disciplinary subject. With the decline of Latin in secondary schools and colleges the Classical Association wished to determine the influence of Latin upon other subjects and abilities. The purpose has been to determine the influence of the study of Latin upon English grammar, composition and particularly the ability to define English words of Latin derivation. Many of the studies have dealt with the relationship between Latin and other subjects and a comparison of persons who have and have not studied Latin. Some investigators fail to take into consideration extraneous factors including the selectiveness of the group which usually chooses Latin. Controlled group experiments have determined the effect of Latin training upon some specific function in other subjects. Most studies report some transfer.

Dallam[1] compared the relative attainments in English of two groups of fourth-year high-school pupils, one of which was designated the Latin group and the other the non-Latin group. His findings led him to conclude that the study of Latin was advantageous to the study of English. Thorndike[2] has reported several studies on the general topic of improvement made by pupils who study Latin and those who do not. One of these studies dealt with pupils in the first year of 56 high schools, who were given Form A of the Thorndike Test of Word Knowledge as a basis of determining the range of vocabulary. The scores on this test were used as a basis of making two equivalent groups, one group composed of Latin pupils, while the other was composed of non-Latin students. During the middle of the school year forms B and C of the same test were given to determine improvement as a result of the study of Latin. Thorndike concluded from the results of these two tests that

[1] DALLAM, M. T., Is the study of Latin advantageous to the study of English? *Educ. Rev.*, 1917, 55, 500–503.

[2] THORNDIKE, E. L., Influence of first-year Latin upon range of English vocabulary, *School & Soc.*, 1923, 17, 82–84.

THORNDIKE, E. L., The influence of first-year Latin upon ability to read English, *School & Soc.*, 1923 17, 165–168.

pupils who study Latin gained more than one and one-half times as much as those who did not study Latin.

Another study dealt with the influence of first-year Latin upon ability to read English. In this case the Thorndike-McCall Reading Scale was used. After the data had been corrected for errors, the results indicated that those who study Latin appear to have some advantage in vocabulary and in reading over those who do not.

Hamblen[1] wished to determine the extent to which Latin might increase knowledge of English derivatives by consciously outlining and adapting classroom procedures for the attainment of this objective. Two groups of equal ability were used, the experimental group being taught with the conscious aim of developing derivative work and the other group taught under usual conditions. Pupils who devoted one-fifth of the class time to derivative work with the aid of notebooks and other devices gained about three times as many Latin-derived words as Latin pupils who were taught under usual conditions. Hamblen suggests the following program for those who would use Latin to a better advantage in improving English ability: (1) provision in textbook for derivation; (2) the teacher's use of a derivative list; (3) the pupil's use of a notebook where derivatives and Latin words are listed from time to time; (4) devoting one-fifth of the class time to a study of derivation; and (5) evoking and maintaining pupil's interest through devices.

c. Other School Subjects.—Thorndike's[2] study of the disciplinary value of high-school subjects is based upon 8,564 pupils in grades 10, 11 and 12. These pupils were measured by a battery of intellectual and academic tests in May, 1922, and again on duplicate forms of the same tests in May, 1923. Pupils taking the tests were required to list the subjects that they had studied during the school year 1922–1923, which made it possible

[1] Hamblen, A. A., Investigation to determine the extent to which the effect of the study of Latin upon the knowledge of English derivatives can be increased by conscious adaptation of content and method, Univ. of Penn., 1925.

[2] Thorndike, E. L., Mental discipline in high-school studies, *J. Educ. Psychol.*, 1924, 15, 1–22, 83–98.

to compare gains of those pupils who studied certain subjects with other pupils who had studied the same and other subjects. Thus the relation between subjects pursued and gains made on the tests could be determined. After allowing a definite number of points for normal intellectual growth over a year's period, for the effect of practice as a result of having taken the test and for the fact that boys excelled girls, the results were studied in their relationship to subjects pursued. The plan was to select two groups of pupils equal in ability, who had taken at least three of the same subjects, the fourth subject being different for the two groups. By comparing the gains (allowing for corrections as indicated), the difference between disciplinary values of subjects was computed. Thorndike's method was to treat any subject to be tested as Study I; if he found several hundred pupils who took Latin, geometry, French and Study I, and several hundred others who took Latin, geometry, French and chemistry, he was able to compare the effect of the study of chemistry with that of Study I. Some results of this study are indicated in Table 19.

TABLE 19.—THE DIFFERENCE IN GAIN BETWEEN A PUPIL TAKING A GIVEN SUBJECT AND A PUPIL OF THE SAME SEX AND INITIAL ABILITY WHO TAKES I OR NOTHING IN PLACE OF IT
(After Thorndike, 1924)

School subjects	Thorndike's symbol for each study group	Corrected weighted average difference
Arithmetic and bookkeeping	IV	2.92
Chemistry, physics and general science	IX	2.64
Geometry, algebra and trigonometry	V	2.33
Latin and French	VI	1.64
Physical training	T	0.66
Civics, economics, psychology and sociology	II	0.27
History, music, shop, Spanish, English, drawing and business	I	0.00
Dramatic art	D	−0.29
Stenography, cooking and sewing	VIII	−0.47
Agriculture and biology	III	−0.90

Table 19 shows that arithmetic and bookkeeping hold first rank and are followed by chemistry, physics and general science. Study group I, represented by history, music, etc., has zero value and is used as a basis of comparison with other groups. The corrected weighted average difference of 2.92 for arithmetic and bookkeeping means that by taking these subjects pupils gain 2.92 more points on the tests than they would have gained had they taken history, music, Spanish and English. As the data indicate, the differences between subjects in disciplinary values are relatively small and show that no group of subjects has much advantage over another.

Thorndike drew the following conclusions:

> By any reasonable interpretation of the results the intellectual value of studies should be determined largely by the special information, habits, interest, attitudes, and ideals which they demonstrably produce. The expectation of any large differences in general improvement of the mind from one study rather than another seems doomed to disappointment. The chief reason why good thinkers seem superficially to have been such by having taken certain school studies is that good thinkers have taken such subjects, becoming better by the inherent tendency of the good to gain more than the poor from any study. When the good thinkers studied Greek and Latin these studies seemed to make good thinking. Now that the good thinkers study physics and trigonometry these seem to make good thinkers. If the abler pupils should all study physical education and dramatic art these subjects would seem to make good thinkers. These were indeed a large fraction of the program of studies for the best thinkers the world has produced, the Athenian Greeks. After positive correlation of gain with initial ability is allowed for, the balance in favor of any study is certainly not large. Disciplinary values may be real and deserve weight in the curriculum but the weights should be reasonable.

The results bearing upon transfer of training in school subjects show that the findings vary with type of subject matter, age and maturity of pupils, method of investigation and most of all with the type of training. Transfer in school subjects may be produced by conscious formulation of rules of procedure and techniques of learning, by the development of desirable traits and attitudes, by adequate organization of subject matter and by special teaching devices.

B. Conclusions from Objective Studies

The extent of research on transfer together with results may be observed in Table 20 compiled by Orata.[1]

Table 20.—Statistical Results of Transfer Experiments from 1890 to 1927
(After Orata, 1928)

Findings	Number of investigations*			
	Laboratory experiments	Classroom experiments	Total	Per cent
Finds considerable transfer......	18	14	32	32.32
Finds appreciable transfer.......	23	26	49	49.50
Finds very little transfer........	1	7	8	8.08
Finds no transfer..............	1	1	2	2.02
Claims transfer but no data given	1	..	1	1.01
Claims no transfer but no data given......................	1	1	2	2.02
Claims no transfer but faulty calculation.................	..	2	2	2.02
Finds transference and interference........................	8	..	8	8.08
Finds interference only.........	3	..	3	3.03
Grand total.................	56	51	107	108.08
Duplication.................	8	..	8	8.08
Net total..................	48	51	99	100 00

* Includes experiments in sensory and perceptual functions, memory and experiments with animals.

Other evidence for transfer has been collected by Orata from correlation studies as indicated in Table 21. Orata found that 61.5 per cent of the correlations were high, that 15.4 per cent were appreciable and that 23.1 per cent were low. The relationship among various abilities and functions raises the question as to whether abilities are specific or general. It may be assumed that in so far as abilities are closely correlated there is a high degree of transfer, although coefficients of correlation

[1] Orata, P. T., *The Theory of Identical Elements*, Ohio State Univ. Press, 1928.

need not indicate causal relationship. The results of correlation studies are similar to those obtained by experimentation. They show that the amount of transfer may range from that which is barely perceptible to that which is pronounced.

TABLE 21.—STATISTICAL RESULTS OF CORRELATION STUDIES
(After Orata, 1928)

Findings	Frequency	Composite frequency	Per cent
Finds high correlation		16	61.5
Among mental abilities in general	1		
Among fundamental processes in arithmetic	6		
Between computation and reasoning	3		
Among abilities in school subjects	6		
Appreciable correlation		4	15.4
Among mental abilities	4		
Arithmetic	1		
Low correlation		6	23.1
Among mental abilities	1		
Among fundamental processes in between computation and reasoning	1		
Among abilities in school subjects	2		
Between neatness and accuracy	1		
Total	26	26	100.0

On the basis of objective investigation, some general conclusions may be indicated.

1. **Transfer has been definitely established.** The studies which show no transfer are practically negligible. Transfer may be either positive or negative. However, most studies show that transfer is positive although the amount based on total learning is probably nearer zero than it is to 100 per cent.

2. **The amount of transfer is greater in the trained group than in the untrained group.** This finding suggests that the amount of transfer is primarily dependent upon the amount and kind of training provided. Indirect transfer is usually positive, although the amount is slight. Transfer of

training is more likely to take place between two situations when the practiced and unpracticed functions are similar.

3. **The amount of transfer varies in different individuals and within the same individual under different conditions.** Factors which produce variability in transfer include the nature and amount of previous training and experience, interest, incentives and desire to transfer. The greatest amount of transfer is concomitant with high intelligence, although intelligence alone does not insure transfer. Children, owing to their greater susceptibility to impression, probably have an advantage in the amount of transfer, although the larger fund of information and experience of the adult makes possible wider meanings and applications. Here as elsewhere in learning situations there are wide individual differences.

4. **Transfer takes place only when there is some conscious effort on the part of the individual.** This finding is common among transfer studies and indicates the importance of consciously generalizing and applying both content and methods of learning while the pupil is studying.

5. **Transfer is enhanced by the development of methods and techniques.** As has been indicated, memorizing itself does not improve with training, but methods and techniques of memorizing and studying may be transferred. This conclusion also applies to other mental processes including perception, observation, discrimination and reasoning. Retention is the means by which transfer is made possible. Unless previous experience and training can be recalled or unless previously experienced reactions to the immediate situation can be recognized, there can be no transfer. Wide experience and factual knowledge do not insure transfer, but they provide a background from which to recall and select and consequently offer a greater possibility of recognizing similarities and making applications.

C. Theories of Transference

Although there has been a tremendous amount of investigation since Thorndike and Judd formulated their respective

theories of transfer, a majority of the points of view may be classified as supporting either one or the other of these theories.

Thorndike's theory, which grew out of his experimental work in 1901, maintains that, in order to have transfer from one situation to another, *identical elements* must be present. These elements include identity of content and method. He also believes that training must be specific. This theory may be stated as follows:[1]

> A change in one mental function alters any other only insofar as the two functions have as factors identical elements. The change in the second function is, in amount, that due to the change in the elements common to it and the first. The change is simply the necessary results upon the second function of the alteration of those of its factors which were elements of the first function and so were altered by its training. To take a concrete example, improvement in addition will alter one's ability in multiplication because addition is absolutely identical with a part of multiplication and because certain other processes, for example, eye movements and the inhibition of all save arithmetical impulses, are in part common to the two functions.

Apparently opposed to the theory of Thorndike is the theory of *generalization* by Judd, who believes that mental functions are closely related and interdependent and that training in one function necessarily affects other functions. He agrees with Thorndike that specific elements should be taught, but that they should be generalized before they are capable of being effectively used in other situations. The theory grew out of an experiment by Scholkow and Judd and was reported under the general title of "The Relation of Special Training to General Intelligence." They performed an experiment in which two groups of fifth- and sixth-grade pupils were required to hit with a small dart a target placed under water. One group of pupils was given full theoretical explanation of refraction of light while the other was uninstructed. At first the two groups practiced with the target under 12 inches of water and in this case there was little difference between the progress of the two groups.

[1] THORNDIKE, E. L., *Educational Psychology*, New York, Columbia Univ. Press, 1913.

However, when the target was placed 4 inches under water the pupils who had been given the explanation of the theory of refraction made fewer errors and more quickly adjusted their aims to the new situation. It was not the practice in the one situation that assisted in accomplishment but an understanding of the generalized theory of refraction. Judd believes that a teacher who has a broad viewpoint of any field of subject matter is able to present facts so that they may be generalized and applied to many situations in school and life. Three quotations serve to make Judd's[1] point of view clear:

> These facts certainly justify the statement that mental functions are interrelated and interdependent in the most manifold ways. Sometimes the training of an attitude aids the positive development of certain other attitudes. Sometimes one function interferes with other functions. Above all stands the fact that every experience changes the individual's capacity for new experiences.
>
> A teacher who has a broad outlook on any field of knowledge will make a single piece of information carry to the student not only a bare kernel of truth, but a whole network of suggestions by which the central truth connects with the rest of the world.
>
> We may make our pupils eager seekers after truth, or we may make of them bigoted little dogmatists. What we do will depend very much upon what we and our interests are. If we believe in specialized functions we shall probably do very little to generalize knowledge in our students. If on the other hand we have broad views of the subject we are teaching and of our task in teaching it, we shall find very little in practical experience to bind us to the narrow view that mental life is made up of water-tight compartments.

The extent to which investigators have supported the theories of identical elements and generalization may be observed from Tables 22 and 23. These tables show that some investigators contribute to both theories while others support various aspects of the same theory. In addition to making general claims for the theory of identical elements, many specialists, as Table 22 indicates, support several phases of the identical element theory including identity of content, identity of procedure and identity of aims or ideals. Table 23 shows that there

[1] JUDD, C. H., The relation of special training to general intelligence, *Educ. Rev.*, 1908, **36**, 28–42.

have been recognized at least 11 not clearly differentiated phases of the theory of generalization, including generalized methods of procedure, ideals, attitudes and thinking.

Methods and techniques of acquiring knowledge and solving problems may be the medium of transfer to many situations. Woodrow found that when he taught methods of memorizing transfer was marked. James believed that transfer in memorizing was limited to improved methods of recording facts; and Gates and Taylor held that improvement is dependent upon acquired techniques of procedure. Foster favored more efficient methods of work; Rugg, the acquisition of specific adjustments to familiar cues of visualization; and Kline and Owens, the use of devices in learning. The possibility of transfer through methods of learning is well established.

TABLE 22.—CONTRIBUTIONS TO THE THEORY OF IDENTICAL ELEMENTS
(Compiled from data by Orata, 1928)

Investigators	General claim for identical elements	Identity of content	Identity of procedure	Idendity of aims or ideals
Brooks	..	X		
Coover	X	X	X	X
Coxe	..	X		
Foster	X			
Kline and Owens	X			
Knight and Setzafandt	X	..	X	
Lewis	X			
Martin	X	X	X	
Poffenberger	X	X	X	
Reed	X			
Ruediger	..	X	X	X
Ruger	..	X		
Sleight	X	X	X	
Starch	..	X	X	
Thorndike and Woodworth	X	X	X	
Wallin	X	X	X	X
Wylie	X			

TABLE 23.—CONTRIBUTIONS TO THE THEORY OF GENERALIZATION
(Compiled from data by Orata, 1928)

Investigators	Generalization of methods of procedure	Generalization of ideals	Generalization of attitudes	Generalization of habits	Generalization of techniques	Generalization of thinking, reflection	Concentration and attention	Formation of associations	Faculties and sympathetic functions	Orientation to situations	Integrative function of nervous system
	1	2	3	4	5	6	7	8	9	10	11
Aiken	..	..	..	..	..	..	X	..	X		
Bair	..	..	..	..	..	..	..	..	X	X	
Bagley and Squires	..	X									
Bennett	X	X									
Brooks	..	X									
Colvin	..	..	X	X	X						
Coover and Angell	..	..	X	..	X	X	X				
Coxe	X										
Cummings	..	..	..	..	..	..	X				
Dallenbach	..	..	..	..	..	..	..	..	X		
Dearborn	..	..	..	..	X	..	..	..	..	X	
Ebert and Meumann	..	..	..	..	X	..	X	..	X		
Foster	..	..	..	..	X	..	X	..	..	X	
Gates and Taylor	..	..	..	..	X						
Hewins	..	..	..	..	..	..	..	..	X		
James	..	..	..	..	X						
Johnson	..	..	..	..	..	X					
Judd	X										
Kline and Owens	..	..	..	..	X	..	X				
Mead	..	X	..	X							
Lewis	..	..	..	..	..	..	X				
Meredith	X										
Peterson	..	..	..	..	X	X					
Ruediger	..	X									
Radossawljewitch	..	..	..	..	..	..	..	..	X		
Ruger	X	X	X	X	..	..	X				
Rugg	..	..	..	..	X	X	..	..	..	X	
Reed	..	..	..	..	..	..	..	X			
Saxby	..	..	X								
Seashore	..	..	X	..	..	..	..	..	..	X	
Sleight	..	..	..	..	X	..	..	..	..	X	
Talbor	..	..	..	..	..	..	..	..	X		
Wang	..	..	..	..	X						
Wallin	..	..	..	..	..	..	..	..	..	..	X
Webb	..	..	..	..	X	..	..	..	..	X	
Whipple	..	..	..	..	X	..	X	..	..	X	
Wiltbank	..	..	..	..	X	..	..	X	..	X	
Woodrow	X										
Wylie	..	..	..	X	..	..	..	..	..	X	
Fracker	..	..	..	..	..	X					

Bennett finds that transfer takes place through conscious generalization of knowledge and of methods of procedure; Coxe, through generalization of rules and principles; and Mead, by conscious generalization of ideals. Generalized principles, methods or attitudes may be the medium of transfer to many situations. Colvin proposes what he terms the cultivation of generalized attitudes toward schoolwork. Ruger

speaks of a change from a self-conscious to a problematic attitude, and attitudes of success deliberately planned, while Saxby advocates the development of the desire to become more observant. Bagley and Squires propose the theory of conscious ideals, Brooks emphasizes ideals of procedure, Ruediger favors indirect improvement of mental functions through ideals, while Ruger believes in ideals of efficiency.

Of the two principal theories of transfer neither explains how transfer takes place although each suggests elements which may transfer. These theories are chiefly descriptive of what transfers rather than explanations of how transfer takes place. Although the two theories have generally been considered contradictory, they describe different phases of the same process. The theory of identical elements tends to describe the process in terms of the lower mental processes where reasoning and problem solving are at a minimum. On this level are found specific habits and skills which function in response to identical stimuli. The theory of generalization operates on a higher mental plane which recognizes similarities and analogies, some of which may be very vague. Transfer on this level requires more thought and imaginative ability. The theory of identical elements deals more with materials on the perceptual level, while the theory of generalization deals more with materials on the conceptual level. The former considers concrete materials, the latter, ideas and abstractions.

The two major theories have had far-reaching influence upon educational practice. Of the two theories, however, that of identical elements has had more direct effect upon educational policies, although as the tables indicate there has been much experimental evidence in favor of the theory of generalization. As a probable result of the theory of identical elements, specific education has been emphasized to the extreme. There has been much job analysis, vocational education and specialization, both in secondary schools and colleges. School men have been eager to analyze not only jobs for prospective employees but individuals as well. Courses in trades, industries and commercial work are typical illustrations of the wide-spread

movement to make education specific and practical. The theory of generalization, which emphasizes problem solving and modes of attack rather than factual information and specific skills, should receive more emphasis. It is clear that neither theory provides a basis for a comprehensive educational program. The identical elements theory tends to emphasize mechanization and automatization while the theory of generalization stresses purposiveness and flexibility.

D. Some Educational Implications

The necessity for the individual of applying knowledge and solving problems places a motivating force behind every subject and stresses the importance of transfer as an objective of education.

1. One of the chief purposes of teaching is to facilitate the transfer process. Pupils are dependent upon teachers for the aims and organization of courses and subjects. Although some pupils may see applications in subject matter because of unusual ability or enriched experience, such transfer is usually incidental. The teacher is the motivating force in effecting transfer not only from subject to subject but from school to life situations. Transfer does not take place spontaneously and should, therefore, be taught from the time the child enters school until the educational program is completed.

2. All subjects possess potentialities for present and future application. Each subject has intrinsic values which may be transferred to situations involving the contributions of other subjects and fields as well as to society as a whole. For that reason every subject may be considered a means for indicating and discovering situations to which its particular phases may be applicable. Both facts and relations should be indicated so that many associations may be formed. No school subject offers much greater opportunity for transfer than any other. The amount of transfer is not determined by the subject but by the manner of instruction and the situation in which transfer is developed. No situation evokes transfer

of all one's training and yet there is no situation that does not provide opportunity for some transfer.

3. **There should be frequent and varied applications of learning materials.** Drill should be used not only to fixate information but to provide opportunity for making wide applications to life situations. The curriculum is so organized for administrative purposes that the pupil is led to think of courses and subjects as separate entities. Unless relationships among different courses and fields of subject matter are pointed out there is little likelihood that they will be perceived. It is commonly observed that even graduate students in universities do not correlate and integrate their thinking so that relationships are determined. They may be proficient when discussing the content of specific courses and yet may be very inefficient when required to indicate the relationship of one course or field to another. Some schools offer general survey courses wherein the attempt is made to unify and integrate the essential contributions of various fields, but this method is not as valuable as developing relationships at the time when individual courses are taught.

4. **Pupils should be trained in the techniques of learning and problem solving.** Most studies have indicated the importance of techniques and methods as a means of enhancing the amount of transfer. When pupils have become proficient in the techniques of learning they are capable of reacting to many learning situations. As a phase of the technique of learning, the problem-solving method is of especial significance. The problem-solving approach when adequately developed will remain a tool long after the pupil's factual information has been forgotten. Knowledge of any kind, when generalized, enriched in associations and made a part of the pupil's thinking, becomes a means for broader application in the solution of problems.

5. **Attitudes and ideals should be cultivated.** Attitudes and ideals influence achievement and readily transfer to school and other life activities. Some of these attitudes include honesty, suspended judgment, wise cooperation, intelligent loyalty, a discriminating taste and an intellectual perspective.

These qualities are developed by training and may transfer directly or indirectly to many situations. Specific and direct training may have limited value. However, ideals of honesty and fair-mindedness may be generalized to the extent that they guide one's conduct in many situations. In discussing the obscurity of the higher relations of transfer, Whipple[1] says: "In the meantime the educator is not justified in resorting to any specific subject of instruction for the purpose primarily of deriving from it indirect training values, but neither is he justified in neglecting to derive from every subject all the training value that it seems to promise."

6. Autonomic and modifiable habits of acting and thinking should be established. Autonomic or mechanical habits are developed largely on the basis of identical elements in a situation, while flexible habits involve the higher intellectual processes and are capable of conscious generalization. In the case of autonomic habits there is the possibility of reacting only to situations which are identical or which produce the same response as that under the situations where the habit was originally formed.

Specific skills developed in trades, industries and commercial work may readily be transferred to situations in which these same skills have been developed. These skills are transferred largely as identical elements but may be generalized to the degree that they may be modified and adjusted to the varying needs and purposes of the individual. For example, in the field of home economics it is more important to establish points of view and attitudes of home making than to teach specific skills, important as they are for routine efficiency. The aim here should be to provide enough specific skills to insure efficiency and yet establish ideals and attitudes which will make possible broad interpretations and applications.

7. Transfer ability varies widely among pupils. Some pupils see relationships more easily than others and are capable of making broad applications of subject matter. Others

[1] Whipple, Guy M., The transfer of training, *Nat. Soc. Study Educ.*, 1928, 2, 179–210.

possess meager imaginative ability and intellectual perspective and see relationships only when they are pointed out. Transfer ability may or may not be associated with superior intelligence as usually measured. Pupils who possess poor transfer ability will necessarily need to make applications through the medium of identical elements, which requires drill and specific guidance. Pupils of superior ability will be able to transfer information through the medium of generalization and reflective thinking, in which case training and guidance may be more general.

E. Interference in Learning

The terms commonly used to describe interference include *retroactive inhibition*, *retroactive interference* and *retroaction*. Skaggs[1] has described the retroactive process as follows: "If any given mental (neural) activity B, following a previous learning process A, works detrimentally upon the retention and recall of learning A we denote the fact by saying that there has been retroactive inhibition." The term may be extended to describe interference in acquisition, retention and transference of learning. Retroactive inhibition has been found in both motor and mental activities and with human and animal subjects. Several theories have been proposed.

1. The Perseveration Theory.—Muller and Pilzecker[2] have proposed the perseveration theory. This theory states that when mental activity has been produced by stimuli the activity remains for some time after the stimuli which evoked it have been withdrawn. In brief, once neural activity has been set in motion, the activity continues for some time after the stimuli have been removed. The theory is supported by two lines of evidence:[3] (1) one type of vigorous mental activity produces as much inhibitory effect as any other; (2) interpolated work introduced 17.2 seconds after learning tends to produce greater inhibitory effects than that introduced

[1] Skaggs, E. B., Further studies in retroactive inhibition, *Psychol. Rev. Monog.*, 1926, 34, No. 161.

[2] Robinson, E. S., Some factors determining the degree of retroactive inhibition, *Psychol. Rev. Monog.*, 1920, 28, No. 128.

[3] *Ibid.*

6 minutes after learning. Within limits, the further the interpolated work is removed from original learning, the less the inhibitory effect.

2. The Transfer Theory.—De Camp[1] proposed the theory that inhibition may be explained on the basis of a modified theory of transfer of training. He compared learning of syllables when there was no interpolated work introduced after learning with learning when there was interpolated work distributed within intervals immediately following original learning. His experiments led him to conclude that the influence of retroactive inhibition is relatively unimportant, although he found some results which indicated a slight retroactive effect.

His view is similar to that of Muller and Pilzecker in that he explains retroactive inhibition in terms of a neural process. To explain the slight retroactive influence found he states:

> Retroactive inhibition may present itself where relatively identical or partially identical groups of nerve centers, neurons, synapses, etc., are involved in learning the series of syllables and in the interpolated mental activity. As the neuron groups have relatively less and less in common, retroactive inhibition may manifest itself less and less.

The theory assumes that in the case of interpolated activity, interference is caused by a certain amount of neural activity, stimulated by the interpolated work, which is carried over into the original learning activity. When the individual attempts to respond to two learning situations alternately, one activity tends to transfer into the other in sufficient amount to cause interference. For example, when French and Spanish are learned alternatingly the Spanish may interfere with the French in such a way as to produce mutual inhibition. The transfer theory differs from the perseveration theory in that retroactive inhibition is dependent upon the similarity of the original learning activity and the interpolated work, rather than the difficulty of the interpolated work, which is one line of evidence in the perseveration theory.

[1] De Camp, J. E., A study of retroactive inhibition, *Psychol. Rev. Monog.*, 1915, 19, No. 84.

3. Webb's Theory.—Webb[1] proposed two explanations of the retroactive influence in terms of transfer without consideration of the continued neural activity after cessation of stimulation. These two explanations are termed the *transfer hypothesis* and the *disruption hypothesis*. According to the transfer hypothesis there are certain elements involved in the original learning activity which may be transferred to the interpolated activity in such a way that recall of the originally learned material is inhibited. According to the disruption hypothesis there may be transfer from the interpolated work to the situation in which the original material is reproduced. These hypotheses are stated by Webb as follows:

Transfer Hypothesis.—The retroactive effect is regarded as a case of transfer. In the maze sequence A-B-A the term retroaction refers to the effect of the acquisition of the B habit upon the subsequent functioning or relearning of the A habit. The transfer hypothesis assumes that this effect is mediated by the simple transference of certain elements of the B habit to the succeeding maze A situation. Theoretically this transference may operate either in an advantageous or detrimental manner. In other words retroaction may be positive or negative.

Disruption Hypothesis.—In the maze sequence of A-B-A we know that transfer obtained in proceeding from A to B; certain elements of the complex A habit have been transferred to and utilized in the maze B situation. The hypothesis assumes that this incorporation of certain components of the A habit into the subsequently acquired B habit must necessarily involve its partial disruption and disorganization.

In support of these two hypotheses Webb cites the findings of his maze experiments. He found transfer in all pairs of mazes employed in his experiments as well as some degree of retroactive inhibition. Retroaction was negative in character in 14 out of 16 pairs of mazes. Transfer and retroactive effects were found to be negatively correlated. Those conditions which produced the greatest amount of transfer effect contributed least to the retroactive effect.

Although the theories of inhibition have not been experimentally verified, most investigators find that their results conform to either the perseveration or transfer theory. The

[1] WEBB, L. W., Transfer of training and retroaction, *Psychol. Rev. Monog.*, 1917, 24, No. 104.

perseveration theory has been widely used to explain retroaction although it is difficult to judge which of these theories has most experimental support. Since the theory of Webb is a modified form of the transfer theory, it may also be classified as transfer. The various theories attempt explanation on the basis of the same principle and there is much overlapping, such that one theory may be used in partial explanation of the other. Experiments under certain conditions show that there is an inhibitory effect, but not sufficient evidence has been produced to determine precisely how inhibition takes place or to what degree it will be made evident under varying conditions and in differing situations. However, retroactive inhibition is established and it is possible to outline some of the conditions under which it may occur.

a. Retroactive influence is dependent upon the degree to which original learning and interpolated activity have been automatized. Inhibitions may be produced when attempting to teach both addition and subtraction simultaneously, or when learning two foreign languages during the same quarter, or when memorizing prose and poetry during the same period. Pyle[1] shows that in card sorting it is uneconomical to form two sets of inhibitory habits at the same time. In his experiments the inhibitory effect was greater at the beginning of the learning and gradually lessened as the habits became more definitely established. He shows that it is better to form one habit and then another.

Culler[2] found that, when individuals practice two opposing associations alternately, repetition of each association before the other is formed tended to produce mutual interference. As the practice effect became greater and greater, the effect of interference became less and less.

Kline[3] points out that the amount of inhibition produced by two different movements is dependent upon the degree to

[1] Pyle, W. H., Transference and interference in card sorting, *J. Educ. Psychol.*, 1919, 10, 107–110.

[2] Culler, A. J., Interference and adaptability, *Arch. Psychol.*, 1911–1912, 3, No. 24.

[3] Kline, L. W., An experimental study of associative inhibition, *J. Exper. Psychol.*, 1921, 3, 290–299.

which they have been automatized, for when thoroughly automatized they may facilitate each other. His method in his own experiments was to measure the inhibiting strength offered by an author and his literature, and states and capitols by recall and current knowledge which could be numerically expressed. His findings show that its influence is largely adverse, the degree of influence being determined primarily by the strength of the association between the two elements involved: (1) if the bond has a recall strength of 1 to 10 per cent, the inhibitory effect is negligible; (2) if the bond has a recall strength of 15 to 40 per cent, the inhibiting power is slight; (3) if the connecting bond has a recall strength of from 45 to 70 per cent, the inhibiting strength approaches its maximum; (4) if the connecting bond has a strength of 75 to 100 per cent, the inhibiting strength is moderate and may in some cases facilitate learning.

b. Inhibition is likely to occur when there is a close degree of similarity between interpolated activity and original learning. Most experiments show that there is the greatest amount of inhibition when there is the closest similarity between interpolated activity and original learning. Skaggs's[1] results indicate that the more similar the original learning and the interpolated activity, the greater will be the inhibitory effect upon the efficiency of recall of original learning; he believes that his results support a transfer theory of retroactive inhibition, which usually implies that the original material and interpolated activity possess some common elements. It is uneconomical to begin two closely related courses at the same time, as, for example, algebra and geometry, or French and Spanish.

c. Inhibition is influenced by the time at which interpolated activity is introduced. Interpolated work[2] introduced immediately following original learning has more detrimental influence upon original learning than work introduced after an interval of time. This law suggests the importance of allowing an interval of rest between two learning situations. For example,

[1] Skaggs, *op. cit.*

[2] *Ibid.*

it is not economical to arrange schedules so that the pupil is required to attend two or more classes in immediate succession. As previously indicated, the closer the degree of similarity between two or more learning situations, the greater will be the inhibitory effect.

d. Inhibitions may occur when the situation is so distasteful as to exert a distracting influence upon the activities of the learner. Frank and Ludvigh[1] show that interference is in direct proportion to the unpleasantness of the situation under which learning takes place. Bunch and Wientge[2] found that the greatest amount of retroactive inhibition occurs for unpleasant material. This principle is illustrated in the case of pupils who are forced to take subjects in which they are not interested, or those who form an intense dislike for the teacher. The mind is so much occupied with a distasteful situation that attitudes conducive to learning are inhibited.

e. Inhibitions may be produced by the commission of errors. Culler[3] found that errors committed during practice tend to cause interfering associations which produce other errors. In some instances he found that the effect of interference from errors was general, causing various errors, while in other instances they had a specific effect, causing repetitions of the same errors in succeeding trials. This condition is often illustrated in the case of pupils who have learned errors in such subjects as music, spelling, arithmetic and grammar, and are attempting to correct them. In so far as the commission of errors leads to habitual responses, interference is pronounced. Errors should, therefore, be corrected before they become habitual.

f. Inhibitions tend to accentuate individual differences. Individuals tend to vary a great deal more when interference is present than when absent, because in interference traits of

[1] Frank, J. D., and E. J. Ludvigh, The retroactive effect of pleasant and unpleasant odors on learning, *Amer. J. Psychol.*, 1931, 43, 102–108.

[2] Bunch, Marion E., and Kingsley Wientge, The relative susceptibility of pleasant, unpleasant and indifferent material to retroactive inhibition, *Gen. Psychol.*, 1934, 7, 137–177.

[3] Culler, *op. cit.*

originality, adaptability[1] and independence, as well as many negative traits, are called into play. A teacher has an opportunity in these situations to identify extreme cases of inhibitory tendencies and to provide individual treatment.

Inhibitions may advantageously be used in the schoolroom in cases where substitutions of response will facilitate learning activity. Teachers may prevent detrimental inhibitions by removing conditions in the learning and teaching situation that distract attention and produce unfavorable attitudes.

F. Summary

Transfer of training is essentially the application of learning. It is a process of acquiring knowledge in one situation and using this knowledge in similar or different situations.

Investigations on motor and mental processes and in school subjects show that transfer is definitely established although the amount is probably nearer zero than 100 per cent. The amount of transfer is always greater in the group which has been given special training; this suggests the importance of guidance and training at every stage of learning. Transfer varies widely among different individuals and in the same individual under varying circumstances. Incentives, interests and the desire to transfer are potent factors in its development. Individuals of high general intelligence have greater potentialities although intelligence alone does not insure transfer. Transfer is facilitated through the development of methods of procedure and the formulation of techniques.

Most studies support either the identical element theory of Thorndike or the generalization theory of Judd. The theory of identical elements assumes that transfer is dependent upon the similarity of the practiced and unpracticed functions. It holds that training is specific, and that abilities manifest themselves as relatively distinct entities. The theory of generalization proposes that transfer is dependent upon the degree to which information and skills may be consciously generalized, that abilities are general rather than specific and that every

[1] *Ibid.*

experience contributes toward the individual's general fund of knowledge and intellectual adaptability. The two theories describe different elements in the transfer process and necessarily complement each other. The theory of identical elements tends to describe the process in terms of specific skills and facts while the theory of generalization emphasizes purposive thinking and problem solving.

One of the primary purposes of teaching is to facilitate the transfer process and all subjects provide a medium for its accomplishment. Teachers may aid pupils in the development of techniques of learning and modes of procedure which will serve as invaluable instruments for attacking new problems and making new adjustments. Ideals, attitudes and habits may be transferred.

In addition to transference there are situations in which interference may be found. Interference is influenced by such factors as the degree of similarity between original learning and interpolated activity, the degree of automatization and the time at which interpolated activity is introduced in the learning situation.

CHAPTER XI

INFLUENCES DETRIMENTAL TO LEARNING

A. Fatigue

The length of time that one can work without relaxation or rest is a matter for conjecture. Improvement curves tend to rise during periods of distributed practice, but what the shape of these curves would be if the same amount of time and energy were utilized at one continuous period is unknown. The supposition is that the curves would not only reach an earlier limit, but that they would tend to decline even though greater effort were expended to continue practice. Some factor operates during continuous work which produces a decline in efficiency. This factor is commonly termed *fatigue.*

1. **Theories of Fatigue.**—There are various factors which influence fatigue and there is wide disagreement among investigators regarding its cause, nature and location.

a. Causes of Fatigue.—The toxin theory assumes that when the organism is continuously active there is a tendency for the accumulation of chemical products in the nature of organic poisons. It further assumes that the cells of the body constantly disintegrate and are replenished by metabolic processes. The more an organ is used, the greater the disintegration of cells and thus the greater the need for replenishment. When disintegration takes place faster than cells can be rebuilt, or when it takes place more rapidly than waste products can be removed, fatigue results.

Fatigue, among early investigations, was considered as some factor which in general affected the muscular system as a whole and particularly the muscles directly engaged in activity. Among the first experimental studies are those by Kronecker,[1]

[1] Yoakum, C. S., An experimental study of fatigue, *Psychol. Rev. Monog.*, 1910, 7, No. 46.

in 1870, who studied frogs' legs under electrical stimulation. After a muscle was weakened by such stimulation until it would no longer respond, its activity could partially be restored by washing it out with a salt solution, massaging or increasing the electrical stimulus. These discoveries led to the fatigue-substance theory which in some form has had wide acceptance. The theory assumes that muscular activity causes the production of lactic acid, potassium, phosphate acid and carbon dioxide which circulate through the system and decrease efficiency. It has been found that any one of these substances when injected into a rested muscle will produce symptoms of fatigue. To remove fatigue toxin from the system there is need for rapid circulation of the blood, an increased oxygen supply and rapid metabolic processes. So long as toxins may be carried away as quickly as formed, fatigue exerts little detrimental effect. When toxins are secreted more rapidly than they can be disposed of, fatigue predominates and it is necessary for activity to cease until nature can restore equilibrium.

The toxin theory was immediately followed by the belief that an antitoxin is produced to combat poisonous substances. As early as 1900 the Germans[1] maintained that adrenal glands produced a substance that enabled one to do apparently unreasonable things in times of emergency without feelings of fatigue. The results of experiments with animals and human subjects lent support to the theory. By injecting antitoxins into guinea pigs fatigue was perceptibly decreased. Children who were required to solve difficult arithmetic problems in a room, the air of which contained antitoxins, suffered less fatigue than those not breathing antitoxin.

Many persons have experienced intense fatigue followed by relief while performing the same task. It is probable that "second wind" may be explained on the basis of physical adjustment. Voluntary muscles are more easily controlled and adapted to sudden spurts of activity than are the involuntary muscles which control the organs of elimination and which are in turn indirectly controlled by activities of voluntary

[1] *Ibid.*

muscles. Any changes in the involuntary muscles from their regular speed of waste elimination require time. Second wind is the adjustment of these organs to the new activity and the restoration of equilibrium between the formation and elimination of fatigue substances.

There is much speculation as to the possibility of overcoming the effects of fatigue through incentives and the stimulation of interest. Bennett[1] believes that there is an inexhaustible supply of energy stored under control of the sympathetic nervous system which can be brought into action in times of emergency. In cases of strong stimuli energy is set free which causes one to perform feats beyond that which seems normally possible.

Two viewpoints of the toxin theory have been proposed. One viewpoint explains fatigue as due to *depletion of* available energy. The other and more common viewpoint is based upon the theory that *waste products* are produced by work. Muscio[2] has presented the two viewpoints in the following statements: 1. "Fatigue may be defined as that condition in which a certain percentage of available organic energy has been transformed into heat or work." 2. "Fatigue may be defined as that condition in which certain chemical products of activity of the nature of organic poisons have accumulated in the organ that has been active." In the discussion which follows fatigue is considered as a condition resulting from continuous mental or physical activity, disease or drugs which produces decrease in efficiency.

b. Kinds of Fatigue.—Most investigators believe that fatigue is both physical and mental. The common expressions "tired of work" and "tired by work" may serve to describe its two aspects. "Tired by work" describes a physical condition, while "tired of work" describes a mental condition. According to this point of view mental fatigue is largely subjective and may include lassitude, mental inertia, ennui, weariness and boredom. Mental fatigue is also characterized by decrease of

[1] Bennett, H. E., *School Efficiency*, Boston, Ginn, 1917.

[2] Muscio, B., Is a fatigue test possible? *Brit. J. Psychol.*, 1921, 12, 31–46.

attention, difficulty of concentration and retarded reaction time. These characteristics are often accompanied by emotional tendencies, including irritability, anxiety and worry. Such symptoms are not reliable indexes of decreased efficiency because they frequently may be overcome by change of attitude and incentive.

Physical fatigue is characterized by muscular incoordination, poor posture, muscular contortions, jerky movements, numbness and general inefficiency. It is more tangible and consequently more easily measured by objective methods. Its best remedy is relaxation, rest or sleep. It may be observed, therefore, that physical and mental fatigue are functionally related. Moderate physical fatigue under healthful conditions tends to stimulate mental activities, while excessive fatigue produces a stultifying effect upon the entire system. This fact was demonstrated during the World War when soldiers at the front, owing to excessive fatigue, slept while marching and performed their duties more as automatons than as thinking human beings. On the other hand, mental lassitude is detrimental to physical exertion of any kind, a familiar example of which is the condition produced by worry.

c. Location of Fatigue.—Santesson[1] maintains that fatigue is due to the wearing down of the motor end plates in the muscles. The high resistance of nerve cells and fibers to fatigue supports this belief. Sherrington[2] believes that fatigue is a blocking that takes place at the synapse. Bills[3] has also recently proposed the principle of "blocking," which he characterizes by inability of subjects to continue work even under especial effort until after a period of rest. In studying the reflexes of a dog, Sherrington found that after cutaneous stimulation for a time in one small area the muscles active ceased to contract. However, if a second place only a slight distance from the first

[1] Yoakum, *op. cit.*

[2] Sherrington, C. S., *The Integrative Action of the Nervous System*, New York, Scribner's, 1906.

[3] Bills, A. G., Blocking—a new principle of mental fatigue, *Amer. J. Psychol.*, 1931, **43**, 230–245.

be stimulated the same reflex may be elicited, indicating that the muscle itself is not in an exhausted condition. On the basis of these and other experiments Sherrington eliminates the possibility of mere sensory fatigue and claims that the origin of "negative induction" (so-called muscular fatigue) is at the synapse.

The effects of muscular exertion upon the nervous system are not so easily studied as muscles themselves. Although there are some who believe that nerve fibers continue to perform even though fatigue is present, there are also many who believe that there are other parts of the body which are influenced by fatigue while the muscles are capable of continued activity. It is probable that all of these viewpoints are partially correct in locating fatigue. The fact that muscles become weakened and often swollen through exercise contributes to the theory that fatigue may be located in muscular tissue. The fact that nerve impulses with the same amount of stimulation may fail to elicit the same response supports the theory of neural fatigue. The fact that the effects of strong lights, odors, excessive heat or cold gradually become lessened under constant stimulation supports the point of view that fatigue may build up resistance to its passage at the synapse. The disinclination to continue mental work under constant mental strain may support the view that fatigue is located in the brain. It is probable that the location of fatigue is dependent upon the type of activity and the location of the stimulus.

2. **Methods of Measuring Fatigue.**—Measurements of fatigue were first attempted in Germany as early as 1870, when Kronecker[1] determined the amount of fatigue generated in the muscles of a frog by the application of an electric current. His work on frogs' legs was supplemented by investigations of Mosso[2] and the invention of the ergograph, which is an instrument designed to measure the strength and endurance of muscles. It was believed that intellectual fatigue could be measured by its effects upon muscular ability. His method

[1] YOAKUM, *op. cit.*
[2] *Ibid.*

received much criticism, although it has been refined and still is used.

Tapping as a measure of fatigue was first used by Gilbert,[1] who required his subjects to tap 60 seconds and counted only the taps of the first and last 5 seconds. The results obtained were not reliable, probably because practice effects were not considered. In 1895 Griesbach's[2] aesthesiometric method of measuring fatigue became popular. Griesbach and his school maintained that fatigue increased as skin sensitivity decreased; the aesthesiometer was an instrument designed to measure space threshold. Schoolwork was extensively used in the early nineties as a measure of mental fatigue. Holmes[3] attempted the measurement of decreased efficiency in work by the use of arithmetic tests and bisection of lines. Computation tests, multiplication and addition in particular, probably have been used more frequently than other kinds and are still considered among the best measures of efficiency in school. Thorndike and his students have contributed much to the refinement of methods of using arithmetical calculations as fatigue tests.

Tests of fatigue may be classified as performance and nonperformance tests. The performance test is based upon the assumption that the individual is required to do something and the nature and amount of what is done is taken as a measure of fatigue. For example, an arithmetic test is a performance test. The nonperformance test consists in measuring certain nonvoluntary responses such as blood pressure and pulse rate. The majority of tests, however, are performance tests. Muscio[4] has classified the two types as follows:

Performance tests.
- 1. Muscular.
  - *a.* Muscular strength tests, including endurance tests, dynamometer tests, ergograph and tapping tests.

[1] Robinson, E. S., and A. G. Bills, Two factors in the work decrement, *J. Exper. Psychol.*, 1926, **9**, 415–443.

[2] Leuba, J. H., On the validity of Griesbach method of determining fatigue, *Psychol. Rev.*, 1899, **6**.

[3] Holmes, M. E., The fatigue of the school hour, *Ped. Sem.*, 1894, **3**, 213–234.

[4] Muscio, *op. cit.*

   b. Muscular precision tests, including steadiness tests, pursuit pendulum tests and dart throwing.
   c. Muscular rapidity tests as tapping.
2. Mental tests.
   a. Algometer tests.
   b. Tests of sensory acuity.
   c. Tests of immediate memory.
   d. Tests of attention.
   e. Tests of apprehension.
   f. Tests of judgment and reasoning.

Nonperformance tests.

1. Variations in blood pressure.
2. Variations in skin reaction (the length of time the skin will maintain a white streak made by drawing a blunt instrument with moderate pressure across its surface).
3. Variations in pulse rate.
4. Variations in physiological reflexes.
5. Variations in psychogalvanic reactions.
6. Variations in excretions.
7. Variations in muscle tones.
8. Calorimetry.

Thus far no measuring instrument has been devised which controls all extraneous factors and provides a valid measure of fatigue. Fatigue is complicated by the presence of so many factors which it has been impossible to eliminate that the results obtained in any type of measurement are questionable. Interest and incentives are influential factors which have not been controlled. Opposed to interest and incentives are ennui and boredom. These factors have not adequately been controlled and consequently no absolute measure of fatigue has been constructed. The instruments of measurement are expensive, require the services of those especially trained and, even when used under the most favorable conditions, give questionable results. Ellis and Shippe,[1] after experimenting with various measures of fatigue for a period of three years, concluded that no tests at that time were reliable either for children or adults.

Muscio believes that all performance tests should be interpreted for variable errors. He believes that the nonperformance

[1] Ellis, C., and M. Shippe, Study of the accuracy of present methods of testing fatigue, *Amer. J. Psychol.*, 1903, 14, 496–507.

tests offer greater possibilities at present, although the tests are impractical, and that various involuntary features measured are susceptible to influences from other sources. It is important to note, however, that the variable errors that influence the performance tests do not influence the nonperformance tests. For example, the results of nonperformance tests are not influenced by practice effects. Muscio goes so far as to recommend that the term *fatigue* be abolished and that there should be an attempt to determine the effect of the kinds and the amount of work upon mental and motor processes. Tests should, therefore, be developed with the purpose of determining the effects of activity and not the presence or absence of fatigue. Any tests which will adequately measure fatigue must segregate it or so isolate associative factors that they may be held constant or their influences eliminated. The methods so far developed are excellent beginnings and are sufficiently accurate to indicate trends and suggest methods for further study.

3. Fatigue and Efficiency.—In order to arrange schedules and work, it is desirable to determine the amount and quality of accomplishment before fatigue becomes apparent. The effects of fatigue have been determined with individuals who have spent long, continuous hours in performing some motor or mental task. Several investigators have tested efficiency by continuing work both when fatigue was barely perceptible and when it had reached its maximum effect.

Arai,[1] after practicing on four-place examples until she became efficient, fatigued herself by multiplying mentally four-place numbers by four-place numbers. She worked for four successive days from 11:00 a. m. to 11:00 p. m. without rest intervals. Her results show a decline in efficiency as noted by the increase in time required to perform the given task and by the increase in the number of errors. Her efficiency slightly declined on each of the four days, although not so much as might have been expected. One reason for the slight decline is that efficiency increased during continuous work. It is also probable that her intense interest, drive and increased effort,

[1] Arai, Tsuru, Mental fatigue, *Teach. Coll. Contrib. Educ.*, 1912, No. 54.

together with additional efficiency due to automatization of processes, account for the small loss that she found.

Painter[1] wished to determine if an individual who had developed a fair degree of efficiency in multiplying mentally a four-place number by a four-place number could continue without rest at mental multiplication until he could go no further, and if when such a point was reached he could then multiply a three-place number by a three-place number. He concluded from the results obtained from himself as subject that one reaches a point of fatigue beyond which any kind of continued activity is impossible.

Arai's and Painter's experiments are similar to several performed by Thorndike and his students. In one study[2] 16 subjects worked continuously from 3 to 8 hours on multiplication of one three-place number by another. Only a few of the subjects did as well at the end of the work period as after rest, the most marked effect of fatigue being manifest after a work period of about 5 hours, and the slightest effect in general after a period of 9 hours.

In another study Thorndike[3] reported results from 89 graduate students on the effect of 4 hours' continuous work in writing poetry. He also took into consideration the "satisfyingness" of the work to the students. Continuous work in this exercise increased gross efficiency, but decreased satisfaction and interest. Rest produced a slight gain in total efficiency but a marked gain in satisfaction and interest. In a further study[4] he reported results of an experiment with a work period of about 2 hours and with two retests, one after a rest of 30 minutes and the other after a night's sleep. It was found that the rest period improved the score, but that a night's sleep improved it to a greater extent.

[1] Painter, W. S., Efficiency in mental multiplication with extreme fatigue, *J. Educ. Psychol.*, 1915, 6, 25–30.

[2] Thorndike, E. L., Mental fatigue, *J. Educ. Psychol.*, 1911, **2**, 61–80.

[3] Thorndike, E. L., Fatigue in a complex function, *Psychol. Rev.*, 1914, **21**, 402–407.

[4] Thorndike, E. L., The effect of continuous exercise and rest upon difficult mental multiplication, *J. Educ. Psychol.*, 1914, **5**, 597–599.

Morgan[1] compared the retention of material learned at the end of a long period of work with that learned at the beginning when the individual was not fatigued. The experiment consisted in having subjects learn English equivalents of German words in one sitting of about 4 hours. After two days the subjects were measured for retention by recall, recognition and relearning tests, the results of which were compared with the different parts of the learning period. The material learned during the first part of the period was retained 18 per cent better than that learned during the last period.

After long practice on the same tasks activities become automatized, thus making it possible to continue work with little effort. Learning new tasks requires more energy than performance of the same task after it has been learned. When children are learning any new activity, fatigue quickly develops. This principle suggests that rest periods should be distributed properly, and that various activities requiring different types of effort be arranged appropriately. Accuracy is more directly influenced by long spells of continuous work than is speed. Habits are not easily formed when feelings of fatigue are pronounced, while in the case of habituated tasks fatigue effects may be slight.

4. **Fatigue and School Schedules.**—Variations in efficiency have been observed for different hours during the school day. If pupils are more efficient at certain periods of the school day, it follows that the more difficult subjects should be placed at hours which are accompanied by the highest degree of efficiency. Winch[2] used efficiency in arithmetical reasoning as a basis for determining the most efficient hour of the school day. His experiments were conducted with children ranging widely in age and intelligence in several infants', girls' and boys' schools. Equivalent groups were formed, one group working arithmetical problems early in the morning and the

[1] Morgan, John J. B., Effect of fatigue on retention, *J. Exper. Psychol.*, 1920, 3, 319–333.

[2] Winch, W. H., Mental fatigue in day-school children as measured by arithmetical reasoning, *Brit. J. Psychol.*, 1911, 4, 315–341.

other group late in the afternoon. He found that work in arithmetic during the late afternoon was practically useless for infant children. For children of about eleven years of age, the efficiency of those who worked in the morning was 7 per cent higher than that of those working in the afternoon. For children thirteen years of age the difference in improvement between those who worked early in the morning and those who worked late in the afternoon was only about 3 per cent. These results show that as children become older fatigue effects produced by time of day become less and less, and in the case of adolescent pupils they may be negligible.

Dawson[1] tested the efficiency of children in multiplying a number of three digits by another number of three digits for various periods of the day over a period of five days, a different set of figures being used each day. The children used for the experiment were distributed into five approximately equal groups. Those in Group A began with a 9:30 period on Monday, followed by a 10:30 period on Tuesday, 11:30 on Wednesday, 1:30 on Thursday, 2:30 on Friday and 3:30 on Monday. The other groups were similarly studied. Dawson found that the efficiency of children as measured by ability to perform

TABLE 24.—SHOWING THE AVERAGE NUMBER OF RIGHT AND WRONG OPERATIONS FOR ALL GROUPS
(After Dawson, 1924)

Work period	9:30	10:30	11:30	1:30	2:30	3:30
Correct						
Mean	100.13	108.47	102.90	100.17	101.69	110.93
P.E.$_m$	±0.798	±0.932	±0.909	±0.875	±0.917	±0.931
D_m	....	8.34	2.77	0.04	1.56	10.80
P.E.$_{dm}$	....	±1.227	±1.208	±1.180	±1.210	±1.226
Errors						
Mean	3.24	3.69	3.83	3.61	3.56	3.93
No. of children	1,200	1,201	1,211	1,209	1,211	1,135

P.E.$_m$ = probable error of the mean
D_m = difference between the 9:30 mean and each of the others
P.E.$_{dm}$ = probable error of this difference

[1] DAWSON, S., Variation in the efficiency of children during school hours, *Brit. J. Psychol.*, 1924, 14, 362–369.

arithmetical operations was fairly constant from 9:30 a. m. until 2:30 p. m.

Pyle[1] made several investigations in city schools of three states to determine the learning capacity at the end of the day as compared with that at the beginning. In all of his investigations he found that the ability of pupils to learn just before dismissal in the afternoon was less than that in the morning. The studies by Gates[2] with adults are in agreement with these findings. The tests used by Gates included auditory and visual memory, substitution, recognition and logical memory. He concluded that the last period in the morning and the middle period in the afternoon were the best periods of the day. The first periods in the morning and the afternoon were the poorest. Gates obtained similar results in experiments with fifth- and sixth-grade children. There was improvement in mental functions until nearly noon, a decline at one o'clock and a gradual increase to three o'clock.

Stainer[3] studied variations in efficiency during the school day and year. In one study his purpose was to determine at what period during the day pupils work at their maximum efficiency and also the number of consecutive weeks a school can advantageously operate. Additions in arithmetic were used as test material and 5-minute tests were given at definite intervals of 45 minutes. The pupils did their regular work in the usual manner, but were required to take time out for the tests at allotted periods. A composite treatment of the results of this study is presented in Fig. 14, which indicates definite trends. Figure 14 shows that pupils work with increasing efficiency for approximately 3 hours after the beginning of school in the morning, at which time they appear to have reached their maximum efficiency. As Stainer points out, the interval between the morning and afternoon sessions (a period of 1½ hours) made possible a substantial recovery. The curve

[1] Pyle, W. H., *Psychology of Learning*, Baltimore, Warwick and York, 1921.

[2] Gates, A. I., *Psychology for Students of Education* (revised), New York, Macmillan, 1931.

[3] Stainer, W. J., Rate of work in schools, *Brit. J. Psychol.*, 1929, 19, 439–451.

begins to decline immediately after the midday interval and, were the work continued beyond 3:45 p. m., it is reasonable to

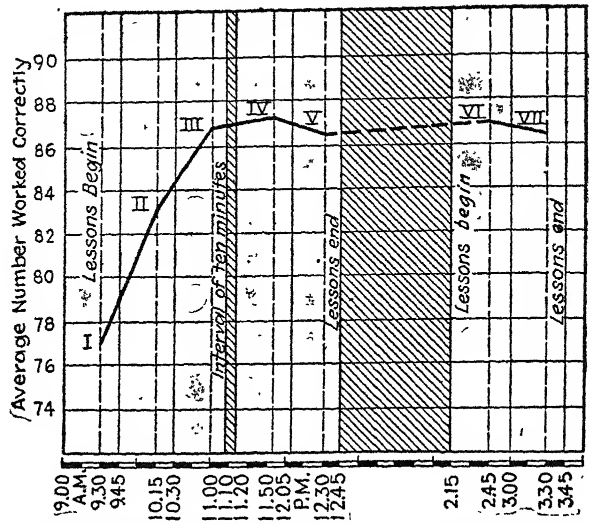


FIG. 14.—Changes of lessons are shown by continuous lines, and times of testing by interrupted vertical lines. (*After Stainer*, 1929.)

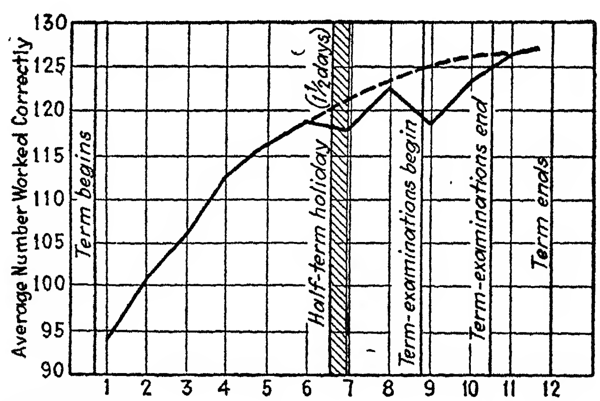


FIG. 15.—Showing average rate of work of pupils at 11:05 A.M. on each Tuesday in the term. (*After Stainer*, 1929.)

suppose that there would be a marked decline. As Stainer suggests, it appears that after about 3½ hours pupils reach their maximum efficiency.

The second part of the study dealt with variations in efficiency in arithmetic during a term of 12 weeks, the pupils being measured on Tuesday of each week. The results are graphically presented in Fig. 15. Interruptions occasioned by holidays and other interferences are indicated in the graph. The curve shows a continuous increase from the sixth to the eleventh test, the assumption being that were these interferences

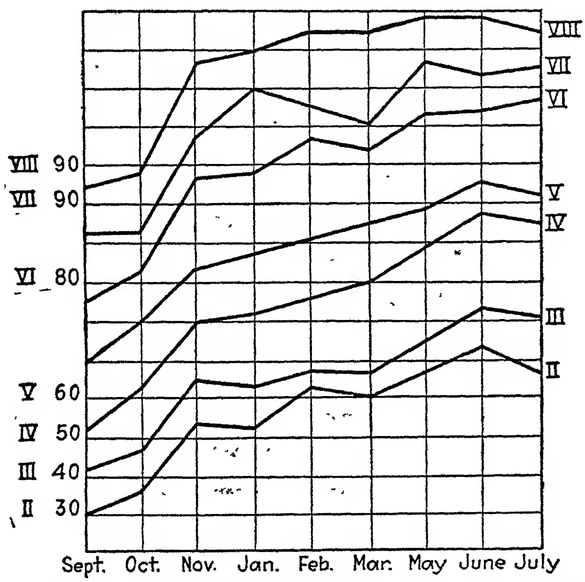


FIG. 16.—Speed-accuracy indexes in spelling. Each square represents five units. The unit from which the graph of each year commences is indicated on the left. (*After Stainer*, 1929.)

eliminated the curve would tend to maintain a continuous line. On the basis of his data it seems that a school may operate for at least 12 weeks without impairment of efficiency.

In a further study Stainer[1] measured the efficiency of pupils in arithmetic and spelling for various months of the year. Some of these results are shown in Fig. 16. For arithmetic the results show that pupils are uniformly lower in July than in June. For spelling efficiency the results are similar, with the

[1] STAINER, W. J., Speed-accuracy competition, *Brit. J. Psychol.*, 1929, 20, 82–89.

qualification that retardation is not so marked in July as in the case of arithmetic. A noticeable feature in arithmetic was the decline in efficiency occurring in the months of January, February and March. Stainer attributes this condition to seasonal fluctuation in mental efficiency. There is some reason to believe that both mental and physical efficiency fluctuate during the year. Rusk[1] believes that for subjects which require much concentration of attention and memory work the most favorable period is from October to January; then there is a decline in mental power which continues to June, after which there is a gradual increase. Rusk believes that climatic conditions and achievement vary inversely. Stainer's results indicate that efficiency is greater in autumn than in spring.

5. Detection and Prevention of Fatigue.—It was once believed that schoolwork was very fatiguing. According to Winch,[2] children eleven years of age fatigue more easily than children thirteen years old, and not so easily as children six and seven years of age. The experiments of Thorndike[3] and Heck[4] show that the usual work of the school produces little fatigue. Heck suggests that fatigue of the school is due largely to unhygienic conditions rather than to schoolwork itself. Results have also been obtained for pupils of varying degrees of intelligence. Kefauver,[5] using 98 pupils eleven, twelve and thirteen years of age, divided them into four groups, according to intelligence quotients. He found that fatigue exerted a greater influence on speed in achievement tests than on accuracy, and that pupils of all levels of intelligence were approximately equal in speed. However, the influence of fatigue on scores was greater for the bright than for the dull group. He believes that effects of fatigue, irrespective of intelligence levels, may be reduced by providing impelling incentives.

[1] Rusk, R. R., *Experimental Education*, New York, Longmans, Green, 1912.

[2] Winch, *op. cit.*

[3] Thorndike, E. L., Mental fatigue, *J. Educ. Psychol.*, 1911, **2**, 61–80.

[4] Heck, W. H., A second study of mental fatigue in relation to the daily school program, *Psychol. Clin.*, 1913–1914, **7**, 29–34.

[5] Kefauver, G. N., The relation of fatigue in pupils of different levels of mentality, *J. Educ. Psychol.*, 1928, **19**, 25–30.

Although fatigue caused by schoolwork may be slight, there are many contributing factors. The symptoms of fatigue may be physical, mental or emotional. Seham[1] suggests that in order to establish the presence of chronic fatigue symptoms should be observed for at least three months; the teacher should note whether the child complains of feelings of fatigue, whether there is an actual decrease in achievement, physical strength and endurance or emotional unbalance. Certain conditions such as forced attention, appearance, slowness of response and general inefficiency indicate fatigue. The teacher may also question the child with regard to his feelings. Of the two methods the former is more reliable because children's feelings may not be accurate indexes of real fatigue. There are, of course, many scientific methods including objective tests in various school subjects but these are not readily adaptable to usual classroom conditions.

In some instances it is not the expenditure of energy which produces fatigue, but inability to use available energy due to the restraints of the schoolroom. Absence of exercise is often more fatiguing than activity. For children to sit quietly in their seats during long periods is conducive to boredom and emotional instability. Among the causes[2] of fatigue in school children the following may be listed:

1. Bright, glaring lights, cross lights or those from the wrong direction fatigue the eyes and may impair vision.

2. Improperly adjusted seats, desks, tables and blackboards place a physical strain on pupils and thus decrease efficiency.

3. Noises and movements which distract attention require additional effort for sustained concentration.

4. Poorly ventilated rooms or excessive temperature cause bodily discomfort and produce emotional fatigue.

5. Malnutrition, overeating, or improper eating habits produce feelings of laziness and lack of energy. Anemia is also definitely associated with fatigue.

[1] Seham, Max, Recognition of fatigue in the school child, *Elem. School J.*, 1928–1929, **28**, 106–113.

[2] Irving, G. R., Fatigue in children, *Elem. School J.*, 1927–1928, **28**, 193–201.

6. Overclothing, ill-fitting or maladjusted garments hamper movements and use extra energy, creating feelings of discomfort which may not be definitely localized.

7. Physical handicaps as nasal obstructions, loose teeth and various tonal and toxic diseases weaken the system and make pupils more susceptible to fatigue.

8. Overplanned routine in which insufficient time is allowed for rest and recuperation.

9. Effort beyond the child's capacity as in trying to keep pace with older children, or to live up to standards set by better qualified pupils.

10. Lack of balance between mental and physical capacity as thinking and writing at different rates of speed requires increased effort for coordination.

Environmental causes of fatigue are unlimited. One's temperament, emotional nature and habits of thinking determine how environment affects efficiency and lends color to one's feelings. One of the most effective remedies for mental fatigue is adaptation to work. Thorndike's experiments show that if one is able to ignore distractions and concentrate attention, efficiency may be maintained under adverse circumstances. Pleasant work, an interest, a goal or a plan increase efficiency and reduce fatigue. Motor activities or short recesses following difficult mental work offset fatigue. Habits of positive and constructive thinking prevent worry and thus reduce fatigue effects. Finally, complete rest and sleep are nature's remedies for fatigue.

B. Loss of Sleep

The most conspicuous features of sleep are relaxation of muscular tone, slower, deeper breathing, weaker pulse rate and lessened arterial pressure. Microscopic examinations show that the nerve cells under working and sleeping conditions possess different properties. Sleep tends to build up both muscular and neurological tissue and consequently is nature's remedy for fatigue. It is probable that sleep is instinctive because it is one of the most universal phenomena of man and animal.

1. Loss of Sleep and Efficiency.—Robinson and Hermann[1] studied the effects resulting from loss of sleep for a period of 60 to 65 hours. Three students were used and such tests as hand dynamometers, tapping, reading letters and mental multiplication were employed. They found that in general loss of sleep produced no definite and consistent decrease in ability upon scores on these tests and believe that it was compensated for by extra effort and incentives. Robinson and Robinson[2] studied a larger group and found similar results. The students were no doubt affected by loss of sleep, but extra effort and compensation kept efficiency relatively high.

Laslett[3] conducted several experiments to determine the effect of loss of sleep on motor and mental activities. His first investigation attempted to measure the effect of 50 hours of insomnia upon rote memory, reaction time and judgment. The results show that in the case of 10 adults the effect of one or two nights' loss of sleep is a matter of individual difference and reserve strength and is also affected by the nature of the tests. He believes that motor tests are not so reliable as mental tests for measuring the effects of loss of sleep, and that extraneous factors exert much influence on the scores of tests in this type of experimentation.

Laslett[4] in another experiment divided his study into two parts. One was the measurement of the effect of a reduced amount of sleep over several successive nights; the other was the critical evaluation of the tests used for experiments of this type. Four subjects underwent a sleep schedule involving a 40 per cent reduction of their usual amounts of sleep for five successive nights. The tests used were systolic and diastolic blood pressure, code writing, addition, pursuit pendulum,

[1] Robinson, E. S., and S. O. Hermann, Effects of loss of sleep, *J. Exper. Psychol.*, 1922, 5, 19–33.

[2] Robinson, E. S., and Robinson, F. R., Effects of loss of sleep, *J. Exper. Psychol.*, 1922, 5, 93–100.

[3] Laslett, H. R., An experiment on the effects of the loss of sleep, *J. Exper. Psychol.*, 1924, 7, 45–58.

[4] Laslett, H. R., An experiment on the effects of the loss of sleep, *J. Exper. Psychol.*, 1928, 11, 370–396.

atoximeter and Thorndike Intelligence Examination. Loss of sleep produced a reduction in the scores for the majority of the tests and especially the Thorndike Intelligence Examination. In the second part of the experiment the subjects remained awake for 72 consecutive hours. There were four experimental and two control subjects. In addition to the tests used in the preceding experiment, pulse rate, sublingual temperature, visual acuity, speed and accuracy of eye movements were determined. In this experiment the subjects showed losses sufficiently large to warrant the use of pulse pressure, code tests, addition test, pursuit meter, atoximeter and Thorndike Intelligence Examination in similar experiments. Table 25 shows some of these results.

TABLE 25.—LOSS PER CENT IN TEST PERIOD IN COMPARISON WITH 3 DAYS IMMEDIATELY PRECEDING A 72-HOUR SLEEPLESS PERIOD
(After Laslett, 1928)

Valid	Loss per cent	Not valid	Loss per cent
Pulse pressure...........	14.8	Pursuit pendulum......	4.8
Code test...............	10.7	Visual acuity..........	2.5
Addition...............	13.8	Letter chart...........	0.0
Pursuit meter...........	8.8	Astigmatism...........	0.0
Atoximeter		Pulse rate.............	0.0
Lateral...............	33.8	Temperature...........	0.0
Positive..............	51.8		
Thorndike I.Q..........	24.5		

Experimenters believe that loss of sleep is detrimental to efficiency, although the detriment cannot be definitely measured because of the inability to determine the amount of reserve energy that is used to overcome loss in efficiency. Various conditions such as worry, drive and incentives influence efficiency that otherwise would be greatly impaired by loss of sleep. Before definite conclusions can be drawn it is necessary to reduce extraneous factors to a minimum and continue experiments over longer periods.

2. The Sleep of School Children.—Speculative discussions regarding the amount of sleep necessary for various individuals

under different conditions indicate that children need more sleep than adults, and that when maturity is reached less sleep is necessary to maintain health. With the aid of teachers and principals, Terman and Hocking[1] studied the sleep of 2,692 children in California, Oregon and Arizona who ranged in age from six to twenty years. The distribution of the sleeping records of these children is shown in Table 26.

TABLE 26.—DISTRIBUTION OF SLEEPING RECORDS FOR 2,692 PERSONS WHOSE AGES RANGE FROM 6 TO 20
(After Terman and Hocking, 1913)

Ages	No. of records	Av. sleep, hours	Ages	No. of records	Av. sleep, hours
6 to 7...........	37	11:14	13 to 14.......	250	9:31
7 to 8...........	147	10:41	14 to 15.......	244	9:06
8 to 9...........	218	10:42	15 to 16.......	201	8:54
9 to 10..........	291	10:13	16 to 17.......	167	8:30
10 to 11.........	307	9:56	17 to 18.......	117	8:46
11 to 12.........	282	10:00	18 to 19.......	43	8:46
12 to 13.........	312	9:36	19............	51	7:47

The study shows that children in the western part of the United States spend more time in sleep than children of similar ages who have been studied in England and Germany. Terman and Hocking explain this difference on the basis of climatic conditions, which permit more outdoor life and a greater variety of activity. Home conditions in the United States are probably superior to those studied in other countries. Their results show that there is no relationship between the amount of sleep, intelligence and school success. Children of low intelligence appear to have as regular habits of sleep as do highly intellectual children, while the literature is replete with examples of geniuses who sleep from 4 to 10 hours a day. However, sleep is an essential requirement for maintaining general bodily vigor and good health. For young children more sleep is necessary, but with increase in maturity smaller

[1] TERMAN, L. M., and A. HOCKING, The sleep of school children, *J. Educ. Psychol.*, 1913, 4, 138–147, 198–208, 269–282.

amounts of sleep are needed to maintain efficiency; for adults 8 hours of sleep per day is usually regarded as sufficient.

C. Lack of Proper Ventilation

Boyle[1] in 1680 showed that air must constantly be renewed to maintain life. Lavoisier[2] demonstrated that if animals were kept enclosed in a small place for long periods of time they would die because desirable elements of the air would be exhausted. According to this theory carbon dioxide must be removed by the use of lime or caustic alkali, or enough good air added to take the place of that which has been lost. Oxygen deficiency and carbon dioxide surplus formed the first theories of detrimental factors in ventilation. The amount of carbon dioxide in the air has been the basis for measuring efficiency in ventilation until recent experiments have shown that other elements should be considered.

1. **Temperature and Humidity.**—In 1905 the Breslau[2] school reported several investigations made by the use of especially prepared rooms and tests. In one instance 60 children were kept in a closed room for 3 hours with a temperature of 66 degrees and a humidity of 50 per cent. No unpleasant symptoms were noted and computation tests revealed no decrease in efficiency even after the carbon dioxide had increased over 200 per cent. When the temperature was raised to 79 degrees and the humidity to 75 per cent the subjects experienced headaches and feelings of depression. When the air was put in motion without changing its contents, headaches and depressions were relieved. When a subject breathed the outside air with the body still in the room, there was no apparent relief. However, when the subject was on the outside of the chamber and breathed the air of the chamber through a tube, relief was immediate. These investigations tended to prove that the detrimental effects of poor ventilation are not

[1] Stecher, L. I., The effects of humidity on nervousness and on general efficiency, *Arch. Psychol.*, 1915–1917, **5**, No. 38.

[2] *Ibid.*

entirely due to carbon dioxide and other poisons in the air, but were determined chiefly by temperature, humidity and air circulation.

The New York State Commission on Ventilation[1] has made intensive studies of the effects of temperature upon intellectual work. The commission studied several hundred individuals in a continuous period 4 to 8 hours daily from one to six weeks. It was found that temperature had a marked effect upon comfort within a range of 68 to 86 degrees, although ability to do mental work remained unaffected. Hines[2] studied the effects of varying degrees of temperature upon efficiency in arithmetic and spelling tests. Three different rooms in three different buildings were heated for one hour to 80 degrees, 75 degrees and 70 degrees respectively. The tests and pupils were so rotated that each group was subjected to the varying degrees of temperature in a definite order. The results indicate that the most efficient schoolwork is done between 65 and 70 degrees. Hines also found that the more the temperature rises above or falls below 70 degrees, the less the efficiency.

2. Oxygen Deprivation.—In 1917[3] a war measure requiring all aviators to be classified according to ability for altitude work caused an investigation to be made in the field of aviation. The subjects were placed in machines so that the amount of oxygen could be increased or decreased without the subject's becoming aware of the change. In the early investigations the subjects were allowed to remain in the machine until they lost consciousness. The tests used involved sensitivity, muscular control, emotions, attention and the more complex processes. One of the most noticeable effects of depleted oxygen supply was muscular incoordination accompanied by tremor. When this continued long enough, there was disorganization of the higher mental processes, and it became

[1] *Ventilation—Report of the New York State Commission on Ventilation*, New York, Dutton, 1923.

[2] Hines, L. V., Effects of schoolroom temperature on the work of pupils, *Psychol. Clin.*, 1909–1910, 3, 101–107.

[3] Bagby, E., The psychological effects of oxygen deprivation, *J. Comp. Psychol.*, 1921, 1, 97–113.

difficult for subjects to control attention. Their muscles first became relaxed, then tense and later unsteady. In the final stages of asphyxiation the subjects seemed to release all restraint on behavior.

Thorndike, Ruger and McCall[1] determined the difference in achievement of pupils when they worked under conditions of "recirculated" washed air instead of "fresh" outside air. Two groups of equal ability were used for the experiment, one group being subjected to outside ventilation from the time heat was provided, and the other subjected to ventilation by circulation in addition to some outside air during the experiment. Their results show that recirculated air does not impair the efficiency of the ability of pupils to learn.

Bagby[2] performed an extensive investigation to test the effect of oxygen deprivation upon motor and mental efficiency. In the case of motor performance his results show that the gradual depletion of oxygen tends to produce tremor and muscular incoordination. Depletion of oxygen tended also to decrease ability to perform certain mental tests involving quick adaptation of attention. When the subjects reached the final stages of asphyxiation it was difficult to concentrate attention upon any task. McFarland's[3] study shows that the first effects of oxygen deprivation may be positively stimulating, but that prolonged exposure leads to sleepiness or to emotional outbursts.

An adequate supply of oxygen in the body is necessary in order that chemical decomposition and restoration of body cells may be effected. Oxidation of fatigue toxins tends to remove fatigue. The amount of oxygen supply necessary is dependent upon the amount and type of activity and the rapidity and amount of energy produced.

[1] Thorndike, E. L., G. J. Ruger and W. A. McCall, The effects of outside air and recirculated air upon the intellectual achievement and improvement of pupils, *School & Soc.*, 1916, 3, 679–684.

[2] Bagby, *op. cit.*

[3] McFarland, R. A., The psychological effect of oxygen deprivation, *Arch. Psychol.*, 1932, 19, No. 145.

D. Drugs, Tobacco and Alcohol

1. Drugs.—Jones[1] conducted an extensive set of experiments on the effect of strychnine on ergograph curves. The experiment lasted 15 days. During the first 4 days 4.2 milligrams of hypochloride of strychnine were given. During the next 4 days 1.8 milligrams were given and the remaining days the subjects were given a mixture containing no strychnine, but resembling it in appearance. This control was supposed to eliminate the factor of suggestion. The larger doses produced a rapid rise in the amount of work accomplished, followed by gradual decline, but the decline did not reach normal until the fifth test. The smaller doses caused a gradual increase that fell below normal on the last set of tests. Poffenberger's[2] results show that ordinary doses of strychnine produce no definite effect upon either motor or mental processes. Probably larger doses would have had effects similar to those found by others.

Hollingworth's[3] results show that speed of typewriting is increased by larger doses of caffeine alkoloid (1 to 3 grams) and is decreased by 4 to 6 grams. The quality of typewriting as measured by errors was superior for the caffeine doses of 1 to 6 grams.

Results by Hollingworth are typical of those found by others with the use of caffeine. He found that up to 4 grams of caffeine was not injurious but with 6 grams the majority of subjects reported nervousness, feverishness, irritability and disturbed sleep. The effect was partly dependent upon the amount of food in the stomach at the time of administering the dose.

The conclusion to be drawn from these experiments is that strychnine and caffeine have a stimulating effect which is

[1] Varrier-Jones, P. C., Effect of strychnine on muscular work, *J. Physiol.*, 1907–1908, **36**, 435–446.

[2] Poffenberger, A. T., Jr., The effects of strychnine on mental and motor efficiency, *Amer. J. Psychol.*, 1914, **25**, 82–120.

[3] Hollingworth, H. L., The influence of caffeine on mental and motor efficiency, *Arch. Psychol.*, 1912, **3**, No. 22.

usually followed by a period of depression. It seems that strychnine and caffeine taken into the stomach in moderate doses cause neither increase nor decrease in motor and mental efficiency.

TABLE 27.—SCHEMATIC SUMMARY OF ALL RESULTS
(After Hollingworth, 1912)

Tests	Small doses	Medium doses	Large doses	Secondary reaction	Action time, hours	Duration, hours
Tapping..........	St.	St.	St.	None	.75 to 1.5	2 to 4
Three-hole........	St.	0	Ret.	None	1 to 1.5	3 to 4
Typewriting						
a. Speed........	St.	0	Ret.	None	Results show only in total days' work	
b. Errors.......	Fewer for all doses			None		
Color-naming	St.	St.	St.	None	2 to 2.5	3 to 4
Opposite..........	St.	St.	St.	None	2.5 to 3	Next day
Calculation........	St.	St.	St.	None	2.5	Next day
Discrimination reaction time......	Ret.	0	St.	None	2 to 4	Next day
Cancellation.......	Ret.	?	St.	None	3 to 5	
S. W. illusion......	0	0	0			
Steadiness.........	?	Unsteadiness		None	1 to 3	3 to 4
Sleep quality, Sleep quantity, General health ...	Individual differences depending on body weight and conditions of administration.					

St. = stimulation; 0 = no effect; Ret. = retardation effect of caffeine on various activities.

2. Tobacco.—Hull[1] studied the effects of smoking on efficiency of 12 physical and mental processes in which he employed both habitual smokers and nonsmokers. Hull's results are significant because of the large number of physical and mental processes measured, the control and supervision exercised and his interpretation of data for extraneous factors. A summary of his results is presented in Table 28.

Hull, in generalizing upon his findings, especially emphasizes the effects on habitual smokers, because it is with this type of

[1] HULL, C. L., The influence of tobacco smoking on mental and motor efficiency, *Psychol. Rev. Monog.*, 1924, **33**, No. 150.

subject that practical interest is centered. It may be noted that only 3 of the 12 processes studied show an unmistakable influence of smoking and two of these, pulse and tremor, are largely physiological. Of the psychological processes addition

TABLE 28.—SUMMARY OF THE PERCENTAGE EFFECTS OF SMOKING
(After Hull, 1924)

Function tested	Nonsmokers			Habitual smokers		
	First post-dosage test	Second post-dosage test	Third post-dosage test	First post-dosage test	Second post-dosage test	Third post-dosage test
Neuromuscular processes:						
Pulse rate.........	_+12.63_	_+ 3.07_	_+ 2.74_	_+ 8.09_	_+ 7.25_	_+ 4.52_
Tremor of hand...	_−29.8_	_−31.2_	_−23.2_	_−38 3_	_−22.3_	_− 4 8_*
Tapping..........	+ 1.35	− 1.14	− .39	− 1.4	− .9	+ .5
Muscular fatigue..	+32.2	+10.1*	+ 6.2*	+ 9.6*	+ 3.7	−12.5
Sensorimotor processes:						
A-Test, speed......	− ?	− ?	− ?	+ .1	− 1.2	− 1.4
A-Test, accuracy..	− ?	− ?	− ?	+22.2	+32.1*	+38.8*
Reading, reaction time...........	+ 1.08*	+ .05*	+ .54*	+ 1.2*	+ .05*	+ .85*
Learning, reaction time...........	+ 4.41*	+ .44*	+ 3.65*	+ .7*	+ .35*	+ 5.55*
Higher mental processes:						
Adding, speed.....	_− 2.94_	_− 3.43_	_− 2.96_	_+ 3 0_	_+ 4.58_	_+ 6 55_
Adding, accuracy..	−26.5	−36.0	−17 5	− 2 4	− 3.4	+ 1.2
Memory span.....	_− 6.38_	− 2.53*	_− 6.46_	− 5.22*	− 1.83*	− 3.95*
Rote learning.....	_− 8.02_	+ 4.33	+ 3.61	−10.1*	+ .2	− 6.2

The effects having a satisfactory statistical reliability are given in *italic* type. Certain other effects which have been judged by the writer as probably reliable, but partly upon other than statistical grounds, are marked with a *. + = stimulation or gain in efficiency; − = loss.

is the only one which is definitely reliable. As Table 28 indicates, however, there are several other processes which are significantly affected and deserve consideration. The two most significant tests of the psychological processes are complex mental addition and rote learning.

The following conclusions by Fisher[1] provide an appropriate summary for the experimental data regarding the effects of smoking:

1. Tobacco smoking causes an immediate increase in pulse rate.
2. Tobacco smoking causes an immediate slight rise in blood pressure.
3. Tobacco smoking causes a slight decrease in steadiness (the ability to hold the hand in a given extended position).
4. Tobacco smoking results in a loss of accuracy of movement but produces greater uniformity.
5. Tobacco smoking retards muscular fatigue.
6. Tobacco smoking has an immediate accelerating effect upon any automatized function, mental or physical.
7. In work requiring a sustaining of attention over a considerable period of time, and involving accuracy and promptness of discriminating responses, tobacco smoking increases the efficiency in the few reactions tested.

3. **Alcohol.**—The use of alcohol, as of tobacco, carries with it certain moral antipathies and the formation of habits that eventually become detrimental. Small quantities appear to have little detrimental effect other than to build up an appetite for larger quantities. Small quantities have certain stimulating effects while larger quantities become poisonous.

Rivers was one of the first to disguise alcohol so that subjects were unable to determine by sight, taste or smell whether the mixture contained alcohol, thus eliminating the possibility of suggestion. He found that small doses ranging from 5 to 10 cc. had very little effect upon motor activities as shown by the ergograph, 40 cc. affected some while 100 cc. failed to affect others. Doses that were large enough to impair motor activity caused a decrease in the amount of mental work as well.

Hollingworth[2] used beer in an effort to determine the effects of alcohol on motor and mental activities. For a control group he used the same beer with the alcohol extracted. The test schedule was so arranged that the effects of alcohol could be compared with performance earlier in the day before alcohol

[1] Fisher, V. E., An experimental study of the effects of tobacco smoking on certain psycho-physical functions, *J. Comp. Psychol. Monog.*, 1927, 4, No. 19.

[2] Hollingworth, H. L., The influence of alcohol, *J. Abn. & Soc. Psychol.*, 1923, 18, 204–211.

was taken, with days when only the control dose was taken and days when neither alcohol nor control was taken. The results of this study are shown in Table 29.

TABLE 29.—INFLUENCE OF ALCOHOL ON MENTAL AND MOTOR EFFICIENCY
(After Hollingworth, 1923)

Function tested	40 to 50 cc. alcohol, change, per cent	66 to 79 cc. alcohol, change, per cent
Pulse	+ 8	+ 10
Steadiness	−68	−241
Tapping	− 7	− 13
Coordination	− 6	− 10
Color naming	− 2	− 7
Opposites	− 5	− 12
Adding	−10	− 10
Substitution	− 4	− 9
Memory	−21	

The results of these studies show that alcohol when taken in large doses impairs the efficiency of every physical and mental process. This effect is more marked in the higher mental processes and with increasingly larger doses. Quality of work is affected more than quantity. The real effect of alcohol does not appear until some time after it has been taken and may last for 48 hours. Individuals differ widely in the amount of alcohol necessary to produce detrimental effects.

E. SUMMARY

Fatigue is a condition resulting from continuous mental or physical activity, disease or drugs, which produces a decrease in efficiency. Most theories explain fatigue in terms of waste products or toxins produced by continuous work. One view of the toxin theory explains fatigue on the basis of the amount of work that may be accomplished before fatigue becomes apparent. Another view is that there are certain waste products which are produced by work. In either case there is the assumption that waste products in the nature of toxins

are produced. Fatigue may manifest itself in either decreased physical or mental efficiency, although both are simultaneously affected. It is probable that the location of fatigue is dependent upon the type of activity and the location of the stimulus.

Fatigue may be measured by performance or nonperformance tests. However, since it is influenced by so many factors which are difficult to control and evaluate, few measuring instruments are satisfactory. Tests in arithmetic and other subjects have been used as a basis of measurement in school. Although fatigue produced by schoolwork may be slight, there are many contributing factors. The symptoms of fatigue in school children may be physical, mental or emotional. The school should detect symptoms of fatigue and provide means for the prevention of its influences.

Sleep is an essential requirement for maintaining general bodily vigor and good health. Sleep tends to build up both muscular and neurological tissue and consequently is nature's remedy for fatigue. Loss of sleep impairs efficiency, although the amount of its influence cannot definitely be measured because of the difficulty of determining the degree of reserve energy used to overcome loss in efficiency. Efficient work is dependent upon appropriate amounts of temperature and humidity. An adequate supply of oxygen is necessary in order that chemical decomposition and restoration of body cells may be effected.

Strychnine and caffeine have a stimulating effect upon physical and mental processes, usually followed by a feeling of depression. Tobacco smoking tends to affect detrimentally several physical and mental processes, although it may have a beneficial effect in performing certain automatized functions and tasks requiring sustained attention over a long period. The effect of tobacco smoking is dependent upon the degree of the habit, the age and maturity of the individual and the amount consumed. Alcohol when taken in large quantities impairs the efficiency of every physical and mental process. When used in moderation there appears to be little measurable effect.

CHAPTER XII

ATTITUDES AND INCENTIVES

Attitudes are determining factors in behavior while incentives are devices for stimulating their development. It is, therefore, pertinent to consider the attitudes favorable to learning and incentives for creating them. The teacher by providing and adapting various types of incentives can aid in overcoming periods of discouragement, which are natural occurrences in the life of every pupil.

A. Attitudes

There is a diversity of opinions as to what constitutes attitudes. This diversity is due both to the intangible nature of the term and to the lack of scientific material available. There are, according to Bain,[1] at least six connotations of the term in psychology: (1) great organic drives, more familarly known as purposes or motives; (2) muscular set or adjustment; (3) generalized conduct; (4) neural set or readiness to adjustment; (5) emotional concomitants of action; and (6) certain verbal responses indicating liking or disliking, acceptance or rejection. The nature of attitudes may be made clearer by referring specifically to some typical opinions. Charters[2] in defining *attitudes* says, "When we speak . . . of developing attitudes in children, we refer to a set of mind towards many things." He further believes that attitudes may be favorable, neutral or opposed. Symonds[3] believes that the term *attitude* has no place in psychology or education and that the terms *habit* or *skill* should be substituted in its stead. He says:

[1] Bain, Read, An attitude on attitude research, *Amer. J. Sociol.*, 1928, **33**, 940–957.

[2] Charters, W. W., *The Teaching of Ideals*, New York, Macmillan, 1927.

[3] Symonds, P. M., What is an attitude? *Psychol. Bull.*, 1927, **24**, 200–201.

"Attitude is not a term used to refer to a specific kind of reaction, but is a name which either duplicates what is already known as habit or skill or is a term which is used to refer to particular features—the readiness or affective side of reaction units."

The variety of opinions expressed by different writers is due chiefly to the loose use of the term *attitude*. The majority of these opinions have been directed, not at the attitude itself, but at its outward manifestation. In these viewpoints, however, may be recognized several elements of common agreement which include the concepts of adjustment, affective states and generalized behavior. An attitude may be defined as a mental disposition of the individual to act in a certain way and is composed primarily of feeling elements. When one expresses an attitude toward an object there is little conscious attempt to analyze all the factors involved in one's reaction or to rationalize about it. Reasoning and reflective thinking[1] play a minor role. Interpreted in terms of behavior, attitudes are tendencies to respond, or emotional concomitants of responses. Viewed in this way, attitudes may be positive, negative or neutral, involving liking, disliking or neither. As suggested by Faris, the attitude may in part be the residual effect of the act, but it remains as a factor which affects consequent activity.

1. Measurement of Attitudes.—Owing to their intangible nature and the subjective factors necessarily involved in the construction of scales and tests, it is difficult to obtain accurate measurement of attitudes. The early investigations depended primarily upon rating scales, scoring cards and questionnaires, which have doubtful reliability and validity. Although early attempts have not been satisfactory, they have provided suggestions for more objective methods of study. Present efforts of research workers are characterized by greater objectivity in measurement and closer supervision of factors which influence behavior. Various traits of personality, types of opinion, qualities of citizenship and social ability have been

[1] DROBA, D. D., The nature of attitude, *J. Soc. Psychol.*, 1933, 4, 444–463.

studied. The chief difficulty encountered in the measurement of such traits is that of separating information about certain traits from practice in the expression of them. Conduct is extremely variable and different types of reactions may be expected from the same individual. A child may make a high score on attitude tests involving conduct and yet not practice that knowledge in a concrete situation. The chief difficulty encountered in measuring attitude is the inability to distinguish attitude from behavior, since attitude is a subjective state which can be measured only by outward manifestations.

Hartshorne and May[1] have constructed scales for measuring dishonesty and deceit. A preliminary report of their more extensive studies is illustrated by the steps which are followed in the construction of such a scale. It is assumed that by the time the child reaches a certain grade in school his mind is crystallized with regard to cheating. He may have a definite attitude against it, or he may favor it, or he may assume a neutral attitude toward it. The assumption is that these sets or attitudes are variables and range from complete neutrality to all degrees of positiveness and negativeness. At one end of the scale are those who are against cheating and at the other those who definitely favor it. A series of statistical criteria is established for the scale which includes the creation of situations in which cheating is possible and detection improbable. The motives for cheating are all neutral in difficulty. The limit of the scale on the positive end is a point of difficulty where no one cheats and on the other end a situation in which all would cheat; the situations are arranged in such a way that all who cheat on one level will also cheat at all lower and easier levels. Finally the obstacles are of such a nature that they can be overcome by the application of time and effort without regard to other attitudes and intelligence. A scale for measuring dishonesty is constructed with these criteria, and the results obtained indicate that it is a valuable instrument for measuring such attitudes.

[1] HARTSHORNE, H., and M. A. MAY, First steps toward a scale for measuring attitudes, *J. Educ. Psychol.*, 1926, 17, 155–162.

Other tests embrace such traits as fair-mindedness and professional and social attitudes, while many deal with the general traits of citizenship. These scales are a natural outgrowth of the development of tests of intelligence and achievement. It was soon discovered that intelligence and educational tests were limited in diagnostic power and that other traits might be of even greater significance as factors affecting behavior. The school should carefully study all the characteristics of the individual. The chief obstacle arises from the fact that many of the most valuable characteristics are the intangible qualities. These qualities include attitudes of thinking, willing and feeling for which we have no accurate measurements, yet they are important factors in conduct.

2. The Training of Attitudes.—Saxby[1] studied the conditions which affect the growth of ideals when direct instruction is provided. Three experiments were performed involving (1) the effect of direct instruction upon the ability to become more observant of common objects of everyday life, (2) the effect of training in quick perception upon the ability to perceive things more quickly at a glance and (3) the effect of training in neatness upon the ability to become neater in home and school work. As a basis for determining the effects of special training, parallel groups which took no training were used as control. In addition to determining the initial ability at the beginning of the experiments, children were tested at various intervals after varying amounts of direct instruction. Although a training period of 6 to 9 weeks appeared to be sufficient to develop a temporary desire to become more observant of everyday objects, 12 weeks' training was necessary to produce any permanent improvement. Twelve weeks of special training in quick perception did not appear, however, to improve the ability of children to see things more quickly at a glance. In the case of those who were trained in neatness there appeared to be some improvement, although a training period of 9 weeks

[1] SAXBY, IDA B., Some conditions affecting the growth and permanence of desires, *Brit. J. Psychol.*, 1917, **9**, 93–149.

was not sufficient to effect any permanent change. Saxby concludes from these experiments that definite improvement usually follows direct instruction, but improvement is not an accurate index of the extent to which an ideal has been developed. It usually requires considerable time in which to develop an effective ideal and even then a different interest may offset all that has been accomplished.

Any program of moral instruction should allow adequate time for the growth and fixation of attitudes and ideals. The effect of training on attitudes and ideals cannot so readily be recognized as that of specific habits and skills. However, by persistent and extended training, favorable attitudes may be developed to the extent that they become guiding criteria for behavior and conduct.

3. Attitudes and Learning.—It is frequently observed that some individuals of mediocre ability achieve superior success while others of greater brilliancy fail. The difference between *ability* and *effective ability* may partially be attributed to the difference in attitude maintained by the pupil.

Wright[1] compared the amount of work accomplished by two groups of students working with different mental attitudes. Under one condition, the students were advised to work as diligently as possible with no idea of securing any specified result. Under the other condition, the students were told to work at a prescribed task as long as their strength would permit. The study shows that a greater amount of work was accomplished when working under the stimulus of a definite goal to be achieved. Peterson[2] studied the effect of attitude upon immediate and delayed reproduction for lists of words. He wished to determine the difference it would make in reproduction if a student knew while reading a list of words that he would later be asked to reproduce them. The active attitude resulted in better performance for both immediate and delayed

[1] Wright, W. R., Some effects of incentives on work and fatigue, *Psychol. Rev.*, 1906, 13, 23–24.

[2] Peterson, Joseph, The effect of attitude on immediate and delayed reproduction, *J. Educ. Psychol.*, 1916, 7, 523–532.

reproduction. When the active attitude was used, a larger number of associations was formed and the students improved their methods of study.

Herriot[1] studied the effects of intellectual and nonintellectual factors upon scholarship of college students. His investigation shows that the major factors associated with scholastic success include: (1) previous preparation; (2) general intelligence; (3) study habits; (4) evaluative-nonevaluative attitude; (5) persevering-vacillating attitude; and (6) self-confident attitude. He believes that attitudes may be comparable in their effect upon scholarship to the more tangible qualities of intelligence and previous preparation, although it is difficult to determine the exact extent of their influence.

When the pupil assumes an active attitude toward work and studies with the determination to achieve and retain, progress is always better than when he has a passive attitude. The will to learn is best fostered by making definite assignments, by setting objectives of achievement and by keeping pupils informed of their progress. Motivation is essentially a process of creating and changing attitudes.

B. Incentives

The term *incentive* describes both the motivating device and the attitude produced by it. The motivating device is the means employed to evoke attitudes conducive to learning. Incentives may consist in either objectively demonstrating achievement, offering encouragement or discouragement or developing competition or cooperation.

Incentives may be intellectual, emotional or social. Intellectual incentives embrace devices for informing pupils of success or failure, or having them work with knowledge of results as distinguished from working without knowledge of results. The emotional incentives include devices which employ encouragement or discouragement, praise or reproof. In this type the pupil may or may not be informed of his

[1] Herriot, M. E., Attitudes as factors of college success, *Univ. Illinois Bull.*, 1929.

success or failure but is influenced by expressions of verbal commendation or censure for his performance. The social incentives embrace devices which influence the performance of the pupil when he is working in a social situation. The pupil may compete with other members of his class or with his own record. He may also compete for an individual or group prize. Teachers use at one time or another all of these incentives as motivating devices.

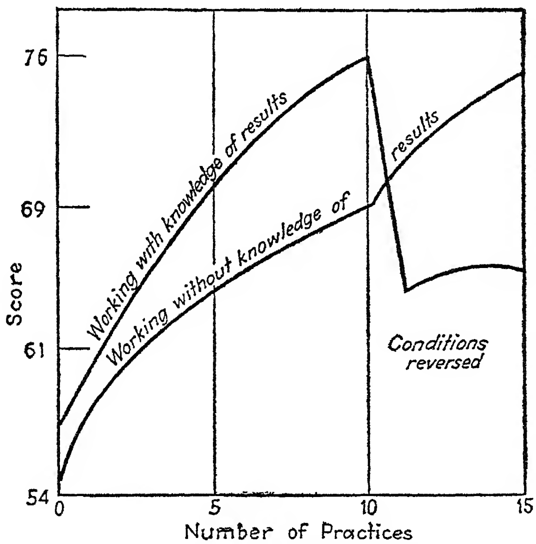


FIG. 17.—Showing the influence of knowledge of results upon progress in making legible "a's." The group working with knowledge of results shows a marked decline when the stimulus of knowledge of results is removed at the tenth practice, while the group working without knowledge of results shows a marked increase when it is informed of progress. (*After Book and Norvell, 1922.*)

1. Intellectual Incentives.—One reason why the pupil makes greater improvement when working in a laboratory situation than in the classroom is that he is constantly aware of success or failure. The numerous experiments which study this type of incentive have been made possible largely through the use of objective tests. The teacher is no longer justified in not having yardsticks which objectify the pupil's present standing and demonstrate his rate of growth.

The extent to which this type of incentive has been studied is shown by Table 30. The general trend of these studies

TABLE 30.—SOME EXPERIMENTAL STUDIES DEALING WITH INTELLECTUAL INCENTIVES

Author	Motivating factors	Subjects	Findings
Allen (1930)	Knowledge of intellectual level	397 subjects, grades 6, 9 and 12 and college freshmen	No appreciable difference
Arps (1917)	Knowledge of results	3 mature students	Positive influence
Arps (1920)	Knowledge of results	3 mature students	Positive influence
Book and Norvell (1922).	Interest and knowledge of results	124 college students	Positive influence
Chapman and Feder (1917).	Knowledge of results	36 5th-grade children	Positive influence
Deputy (1929)	Knowledge of results	College freshmen	Positive influence
Gilliland (1925)	Knowledge of results	College students	Positive influence
Harrelson (1923)	Knowledge of results	26 college students	Positive influence
Holmes (1928)	Honor rolls	High-school students	Positive influence
Jersild (1929)	Examinations	74 to 126 college students	Positive influence
Knight and Remmers (1923).	Knowledge of results	10 college freshmen and 54 juniors	Positive influence
Myers (1915)	Knowledge of results	26 college women	Positive influence
Panlasigui and Knight (1930).	Knowledge of results	4th-grade pupils	Positive influence
Ross (1927)	Knowledge of results	59 college students	Positive influence
Spencer (1923)	Knowledge of results	4 college students	Positive influence

indicates that the method of displaying results of pupil achievement is a positive motive for producing improvement. Objective records of the progress of pupils, with opportunity for comparison of their own present records with previous attainments, give personal meaning to the child's schoolwork.

Knowledge of results is effective for all groups, whether in the lower grades of the elementary school, in the university, among boys or girls, or among individuals of high or low intelligence. When pupils are informed of the quantity and quality of performance, their work assumes significance because they are able to diagnose achievement.

2. **Emotional Incentives.**—Examples of emotional incentives are found in studies which use praise or reproof, encouragement or discouragement, as motivating devices. The teacher employs commendation or censure as a means of influencing the pupil's work. It is one thing to inform the pupil of his progress and another to praise or reprove him for good or poor performance. It is clear that the two types of incentives may produce the same result, but the devices are different. When intellectual incentives are employed, the pupil is able to diagnose his own achievement and become motivated as a result of his own intellectual efforts. When emotional incentives are used, there is commendation or censure which is intended to produce an emotional response in the pupil.

Sarcasm, commendation and censure have long been used as motivating devices. Schoolwork has often been considered as something to be endured, and pupils were not expected to receive encouragement from teachers. Commendation for good performance smacked of soft pedagogy, and pupils were thought to become egotistical if they received encouragement from their superiors. This practice of making schoolwork unpleasant was not only common among early teachers but exists in many schools today where pupils may never feel that they are succeeding.

Praise is better than reproof as an incentive to diligent work. However, both praise and reproof may effectively be employed as motivating influences, though praise is better from the standpoint of both immediate and remote returns. Insincere praise will defeat the purpose for which it is intended. In some instances the teacher who habitually commends work of any quality may find that she is endangering her own standing in the opinions of the pupils. The extent to which praise and

TABLE 31.—SOME EXPERIMENTAL STUDIES DEALING WITH EMOTIONAL INCENTIVES

Author	Motivating factors	Subjects	Findings
Briggs (1927)	Praise and censure	300 graduate students	Praise superior
Gates and Rissland (1923).	Encouragement and discouragement	74 college students	Encouragement more effective
Gilchrist (1916)	Praise and reproof	50 college students	Praise more effective
Hurlock (1924)	Praise and reproof	106 4th- and 6th-grade children	Praise more effective
Hurlock (1925)	Praise and reproof	257 white and 151 colored children in grades 3, 5 and 8	Both praise and reproof effective but praise more effective
Laird (1923)	Various types of incentives	92 college freshmen and sophomores	Negative incentives detrimental, positive incentives beneficial
Laird (1923)	Same as above	Same	Same
Rexroad (1926)	Punishment by electric shock	80 college students	Positive influence

reproof may be used is also governed by individual differences in pupils and teachers. Some pupils respond better to censure than to praise, and there are some teachers who because of certain personality traits can neither effectively commend nor reprove. It is better to make some comment, regardless of its character, about a pupil's work than to assume a neutral attitude. Although reproof is less effective than praise, it can be used more advantageously with mature pupils than with young children. Dull pupils appear to be more affected by praise, and bright pupils by reproof. Boys appear to be more affected by reproof and girls by praise. In general the positive incentives are better than negative incentives for all ages, grades and levels of intelligence.

a. Incentives for High-school and College Students.—Laird[1] had 92 college students give in detail their reactions to the

[1] LAIRD, D. A., How the high-school student responds to different incentives to work, *Ped. Sem.*, 1923, **30**, 358–365.

various kinds of incentives used by their former high-school teachers. The students were freshmen and sophomores and consequently had been away from their high schools for only a short time. Some of the types of incentives used by these high-school teachers are listed by their students as follows:

1. Reprimands before other students.
2. Reprimands made in private.
3. Sarcasm before other students.
4. Sarcasm used in private.
5. Private ridicule.
6. Public ridicule.
7. Low grades as stimulus.
8. Extra work as incentives.
9. Conferences with parents.
10. Corporal punishment.
11. Parents' attitudes as incentives.
12. Friendly conferences.
13. Public praise.
14. Remission of assignments.
15. Love affairs.

In a further study these students were asked to give their reactions to the types of incentives employed by their college teachers.[1] The positive incentives such as friendly conferences with students and parents had the effect of producing attitudes favorable to efficient study, while negative incentives such as sarcasm and reprimands before other students failed to achieve their purpose. The positive incentives tended to stimulate greater effort and to produce more pleasure from school life.

3. Social Incentives. *a. The Influence of the Co-working Group.*—Allport[2] studied the influence of the group upon association and thought. Results were obtained from individuals working alone and from members of a co-working group. The presence of a co-working group was decidedly favorable to the speed of free association. However, the influence of the group varied according to the nature of the tasks involved. In

[1] LAIRD, D. A., How the college student responds to different incentives to work, *Ped. Sem.*, 1923, **30**, 366–370.

[2] ALLPORT, F. H., The influence of the group upon association and thought, *J. Exper. Psychol.*, 1920, **3**, 159–192.

mechanical tasks the group influence was more potent than in those involving the higher mental processes. In tasks which required judgment and reflective thinking, the presence of the group tended to distract. Individuals of a nervous and emotional nature tended to succumb to the influence of the group and did not profit by its presence. The slow worker was more favorably affected by the group than the comparatively rapid individual. Although the presence of a co-working group was an incentive for speed and associations, it was unfavorable to the quality of these functions.

b. Group Rivalry.—Hurlock[1] studied 155 children in the fourth and sixth grades using a modified form of the Courtis Research tests in arithmetic. The scores made by the rivalry group exceeded those of the control group at all times during the experiment. The younger children responded better to rivalry than did the older children. Rivalry also proved to be more effective for inferior children. However, when age, sex and intelligence were considered, rivalry was an effective incentive for children in these grades. Rivalry created a desire to compete with children of the same age and helped to develop a cooperative spirit.

Whittemore[2] determined the influence of rivalry upon performance in a mechanical and mental task. In one case students were urged to get as much work done as possible and to beat their fellows, and in the other they were told to get as much done as possible but not to try to beat their fellow workers. All individuals did more work when competing than when not competing. Students least capable in speed profited most from competition. The character of the competitive process is described by Whittemore as follows:

> Competition on a task commences with an adjustment period in which the subjects either report a conscious effort to orient themselves to the task, to build up with speed and quality in preparation for future competi-

[1] Hurlock, E. B., The use of group rivalry as an incentive, *J. Abn. & Soc. Psychol.*, 1928, **22**, 278–290.

[2] Whittemore, I. C., Influence of competition on performance, *J. Abn. & Soc. Psychol.*, 1924–1925, **19**, 236–253.

tion of a social sort, or conscious attempt to discover their probable position in ability relative to opponents in preparation for more intense rivalry. Competition with the group at large is less frequent than competition with a particular individual. That member of the group who has a given skill in a given subject is the one who tends to be singled out as a principal rival.

TABLE 32.—SOME EXPERIMENTAL STUDIES DEALING WITH SOCIAL INCENTIVES

Author	Motivating factors	Subjects	Findings
Allport (1920)......	Influence of group	26 upperclassmen and graduate students	Group increases number but decreases quality of ideas
Farnsworth (1928)..	Influence of group	20 to 36 college students	Students working alone slightly superior on difficult items
Gates (1924)......	Influence of group	College students	Size of group had no influence except on most difficult task
Hurlock (1928).....	Group rivalry	155 children, grades 4 and 5	Rivalry group gained 40 per cent more than control group
Maller (1928)......	Cooperation and competition	1,538 children, grades 5 to 8 inclusive	Working for self more effective than working for group
Sherman (1929)...	Verbal suggestion on perseverance	65 subjects, 6 to 16 years of age	Suggestions most effective with youngest and oldest
Sims (1928)........	Individual *vs.* group rivalry	126 college students	Individual motivation superior to group motivation; latter is only slightly superior to no motivation
Travis (1925).......	Influence of group	22 college students	Superior score due to group influence
Travis (1928).......	Influence of group	25 subjects	Superiority in number of associations when working alone
Watson (1925).....	Group *vs.* individual thinking	108 graduate students	Group product, in groups numbering up to 10, is superior to individual production
Weston and English (1920).	Influence of group	10 college upperclassmen	Group influence significant
Whittemore (1925).	Competition	4 college women and 8 college men	Average percentile of gain under competition over noncompetition is 26. Quality of work better under noncompetition

c. *Individual versus Group Rivalry.*—Sims[1] compared the relative efficiency of individual and group motivation. In individual motivation the pupil competed against his own record, while in group motivation the pupil as a member of the group competed against another group. Two experiments were performed—one using substitution as a test and the other the rate of reading. The group used as control improved 102 per cent in substitution, the motivated pupils, 109 per cent, and the individually motivated group, 157.7 per cent. The reading tests showed similar results.

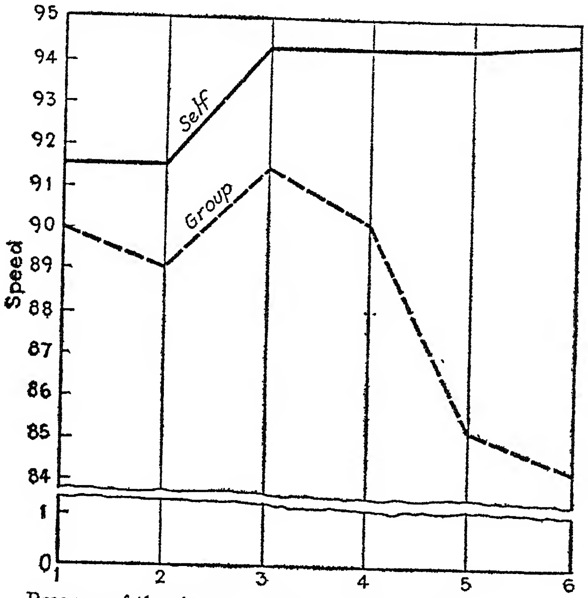
Maller's[2] experiment is based upon results obtained from a behavior test and objective ratings furnished by the Character Education Inquiry. The test materials consisted of a large number of simple additions, and were designed to measure speed of work under the following forms of motivation: (1) practice work in which the pupils were told not to write their names on their papers as their scores would not count, that the examples in arithmetic should be done for practice only; (2) competition in which a speed test was devised and pupils were told that they would be shown a list giving the rank of each child; all were urged to attain a high score, prizes being used as incentives to attain this end; (3) cooperation in which a contest was arranged between two parallel groups. Children were not told to write their names, but the name of their classrooms was placed on their papers. The experiment was conducted with 814 children, and an additional 734 cases were used as comparative control. The children represented all social classes and were from grades 5 to 8 inclusive.

The efficiency of those working under the stimulus of competition was in every case greater than it was for those working under the stimulus of cooperation. The average child achieved 32.4 examples more in 12 minutes of work for himself than in the same amount of time for his group. The curves of those

[1] SIMS, VERNA M., The relative influence of two types of motivation on improvement, *J. Educ. Psychol.*, 1928, **19**, 480–484.

[2] MALLER, J. B., Cooperation and competition, *Teach. Coll. Contrib. Educ.*, 1928, No. 384.

working for self rose with practice while those working for the group consistently declined. When pupils were allowed to choose between working for self and for the group, they chose the group in 26 per cent of the cases and the self in 74 per cent.



Progress of the six test units of work for self and group.
FIG. 18.—The speed of work for self and group during six test units. (*After Maller*, 1928.)

Maller's experiment forcefully demonstrates that pupils in the elementary school respond more efficiently to an incentive which is personal rather than group in nature. Prizes which teachers offer for superior achievement will be more impelling when offered for individuals than for the class as a whole, and when pupils are given the opportunity of choosing they will select this method. The permanency of the interest manifested as a result of incentives will also be greater when individual members are working for self than when working together for the same goal. Maller's experiment shows that cooperation and competition have essentially the same influence during the initial stages of learning, but, as the work continues, those who

work for self improve rapidly while those working for the group of which they are members show consistent decrease in efficiency.

It was also found that there will be greater cooperation in those groups which are relatively homogeneous with respect to age, social factors and intelligence. Since competition rather than cooperation is more effective as an incentive, there is a question of the efficacy of homogeneous classification and sectioning of pupils for classroom teaching. Pupils achieve more when they are competing against their own individual records or against those whom they consider superior. Both cooperation and competition are developed in accordance with the principle of practice. If cooperation is desired, there should be opportunity for the exercise of cooperation in the school and home. Likewise, the practice of staging contests, awarding medals and honors and keeping records of individual performance tends to develop the spirit of competition.

4. The Evaluation of Incentives.—The value of any incentive is dependent upon the amount and character of the activity it produces. It is probable that in any typical schoolroom several incentives are simultaneously used. Incentives should be varied if they are to produce the best results. The criteria which should be used in judging the value of any incentive have been outlined by Robbins[1] in the following questions:

1. Is it suited to the pupils in their present stage of development?
2. Will it reach few or many?
3. Is it likely to have force for a short time only, or to be relatively permanent? Will it continue to be useful as pupils grow older?
4. Is the future sacrificed for the present?
5. Is a real interest in the subject being developed or is the pupil being encouraged to form a permanent distaste?
6. Will proper feelings among pupils be emphasized, or will animosities arise?
7. Is the work in other subjects likely to be improved by the attitudes growing out of this motive as used here?
8. Will the pupil have an increased feeling of good will toward the teacher or one of dislike and resentment?

[1] Robbins, C. L., *Will to Work*, Chicago, Row Peterson Co., 1928.

9. Will the motive create an attitude that demands superior work? Is the pupil willing to endure the unpleasant and disagreeable in order to secure mastery?

10. Does the motive arise from base selfishness and vanity or from something better?

11. Is the motive properly related to other persons—students, family, teacher, taxpayers, etc.?

12. Is the motive derived from the normal situation, or is it external?

13. Has it the character of a bribe, or is it the normal result of work?

14. Is the satisfaction to be derived worth while?

15. Will it bring the satisfaction in genuine achievement which is reasonably certain to follow good work?

16. Does the use of the motive show proper consideration of the whole work situation, or is it a mere attempt to substitute tinkering for professional craftsmanship?

C. Summary

Attitudes are potent factors in school attainment, contributing toward success or failure, depending upon the type of attitude. The school is expected to create desirable attitudes and to modify those not favorable to learning. The desire to do well, seriousness of purpose, emotional stability and confidence are some of the attitudes favorable to learning. The training of attitudes is an extended process, and teachers may not expect to realize in a short time returns on their efforts. Attitudes are developed in accordance with the laws of learning, and pupils should have frequent opportunities for practicing those which are desirable.

Incentives are devices employed to evoke attitudes favorable to achievement. Leuba[1] has described incentives in the following statements:

1. A goal or evidence of progress toward a goal.
2. A mark of distinction, such as a medal or title.
3. A material reward, such as candy or golf sticks.
4. Other persons working at the same tasks whose performance can be compared with one's own (rivalry).
5. Words, expressions, or attitudes of promise, approval, or encouragement.

[1] Leuba, C. J., A preliminary analysis of the nature and effects of incentives, *Psychol. Rev.*, 1930, **37**, 429–440.

6. Words, expressions, or attitudes of blame, disapproval.
7. Words, expressions, or attitudes of deference, obedience, or submission (power over others).
8. Words, expressions, or attitudes of attention, or recognition.
9. Novel stimuli, such as those impinging upon the discoverer or upon anyone engaged in work of a creative nature.
10. Persons or places frequently associated with any of the above (some form of altruism and performance of a task for its own sake).

Knowledge of results is a positive motivating factor for all ages, grades and levels of maturity and especially for children. The pupil who is informed at regular intervals concerning his progress will have a better attitude toward his work and will more readily improve his methods of study.

Of praise or reproof, encouragement or discouragement, as the motivating influence, the positive suggestion, praise and encouragement, is better regardless of age, sex, grade or degree of intellectual maturity. Pupils of low intelligence are more favorably affected by approval and are more sensitive to disapproval, but a comparatively slight difference is noted for any intellectual level. Both praise and reproof are effective as incentives for greater effort, but pupils prefer praise and it creates a more permanent learning attitude than censure and rebuke. A neutral attitude toward the pupil's work has either a negative or neutral effect.

The presence of a co-working group increases the number of ideas, but the quality of performance when the individual is working alone is superior to that in the presence of a co-working group. Although group rivalry is an effective form of incentive, individuals tend to improve to a far greater extent when they are working for themselves than when working for the group of which they are members. Rivalry with one's own record or with individuals of equal or superior ability is conducive to greater improvement than group rivalry.

CHAPTER XIII

ATTENTION AND INTEREST

A. Attention

During all conscious states the individual is attending to something. Attention may be vague and fleeting as in day-dreaming, each idea holding the focal point of attention for an instant, but diverted as soon as another appears, or it may be intense as in solving a problem where ideas are evaluated. As a light which is focused is brightest at the point of focalization and gradually diminishes, so the nearer a stimulus is to the center of attention, the more vivid the consciousness of its presence. To attend to a stimulus is to hold that stimulus in the focus of consciousness.

1. Kinds of Attention.—It is probably instinctive to attend to loud noises, moving objects or sudden changes. Although the environment furnishes many kinds of stimuli to which attention may be given, the specific stimuli to which attention is directed are determined largely by training. Children who live in a city and habitually cross the streets develop the habit of attending to sound and motion in the traffic. The ability to attend is partly innate and partly acquired.

Attention may be involuntary or voluntary. Involuntary attention is spontaneous and is due chiefly to the hereditary tendency to note extremes, intenseness and prolongations. Some stimuli, because of their quality, may attract attention even though one attempts to concentrate upon other stimuli. Involuntary attention is illustrated by attention to the sudden closing of a door, the ringing of a bell, a scream, a whistle, a sudden motion or to anything unusual that may be perceived by the usual organs of reception. The object is of such an impelling nature that one cannot help attending. Under some

circumstances the sudden cessation of sound or motion will attract attention. Any stimulus, because it is unusual, forces itself upon the consciousness and changes the focus of attention. When the attention is focused upon one stimulus, involuntary attention may become a distraction and produce annoyance. In other cases involuntary attention may relieve strain and reduce fatigue.

Voluntary attention is that type of attention which is directed by the will power and purpose of the individual. It is influenced by interest in the stimulus, a goal to be reached or a desire to be accomplished. The greater the intensity of voluntary attention, the less effective are distractions. Concentration for study and for many of the duties of life requires voluntary attention. After one has developed the habit of directing attention to a task, voluntary attention may assume many of the characteristics of involuntary attention. The individual may become so interested in the task that he finds it easier to attend than not to attend.

2. The Measurement of Attention.—The degree of attention is usually determined by some means of distraction. The distractor method uses some method of splitting attention such as loud noises, bright lights, spoken words or sudden movements across the range of vision. The efficiency of the individual is determined while he is engaged in some work which requires attention such as canceling *a*'s, adding numbers or copying an assignment. The difference between the individual's normal performance and that during moments of distraction determines the degree of attention. The method assumes that the greater the degree of attention, the less effective are distracting influences.

Since the conditions of attention may be varied and subjected to quantitative gradation, Woodrow[1] has suggested the term *detractor* as a supplement to *distractor*. Attention in the case of detractors may still be directed toward a task with sufficient concentration to continue performance and at the same time

[1] Woodrow, H., The measurement of attention, *Psychol. Rev. Monog.*, 1914, 17, No. 76.

may partially be directed toward other stimuli in the immediate environment. The attention is detracted so that, instead of one object standing out distinctly from all others, a larger number of sensations is less clearly received. A distractor causes a shift in the direction of attention while a detractor reduces the degree of attention without causing a shift in the focus.

Several means of measuring attention have been employed. Reaction time has been a common form of measurement. When distractors are used there is a break in attention and a momentary cessation of performance, and the time taken to return to the task is considered the measure of attention. Distractors and detractors tend to decrease intensity of concentration and retard reaction time. Reduced attention may be caused by objective stimuli from without or by wandering of attention caused by some attitude or disposition of the subject. The measurement of attention by reaction time assumes that during periods of intense concentration the individual is performing at capacity rate and any deviation of this indicates fluctuation in attention.

McComas[1] seated his subjects before a ground glass window behind which were four electric bulbs colored red, green, blue and yellow. The subjects were asked to press a key as soon as a light was flashed in a window; this turned off the light and automatically turned on another light, which when extinguished turned on still another light, and so on. His findings show wide variations in speed and accuracy of reactions by different individuals and practice effect for some.

Attempts have been made to measure the degree of attention by recall. Wilcocks[2] believes the amount of recall is influenced by the degree of attention given to content during learning, and he has attempted to measure the degree of attention by accuracy of recall. Recall and the degree of attention are not synonymous, but it is probable that the amount of recall is

[1] McComas, J. C., A measure of attention, *J. Exper. Psychol.*, 1922, 5, 1–18.

[2] Wilcocks, R. W., The effects of an unexpected heterogeneity on attention, *Gen. Psychol.*, 1928, 1, 266–319.

directly influenced by the degree of attention both during learning and at the time of recall.

Other objective methods of measurement include noting the number of errors and omissions, and time taken to learn. Subjective methods used by teachers include noting the responses of pupils during the recitation, the number and kinds of notes taken, general attitudes and the frequency and type of questions.

Hovey,[1] using the Army Alpha Intelligence Test, found that distractors have little effect upon higher mental processes and that there was no relationship between intelligence and susceptibility to distraction. Hovey, however, did not take into account practice effect, knowledge of the purpose of distractors and the law of diminishing returns as the subjects became more accustomed to the various forms of distractions. The chief difficulty in studying attention by means of distractors is that no distractor has so far been devised which will exert an equal and continuous effect during its use. The effect of distractors is also influenced by the physical and mental condition of subjects. Distractors may have a relatively slight influence on some occasions while in others, owing to the physical and mental condition of subjects, even slight distractors may cause wide fluctuation in performance.

Sengupta and Sinha[2] believe that detractors are not adequate measures of attention because their subjects worked better in groups than when isolated. They believe that the extra effort necessary to avoid disturbances of the group makes it possible to intensify attention given to a specific task (a compensatory phenomenon). The increased attention which causes greater vividness of the task produces better performance. It is probable that the influence of a co-working group prevents daydreaming and wandering attention. It is also probable that solitude may become a stronger detractor than mild

[1] Hovey, H. V., Effects of general distraction on the higher thought processes, *Amer. J. Psychol.*, 1928, 40, 585–591.

[2] Sengupta, N. N., and C. P. Sinha, Mental work in isolation and in groups, *Indian J. Psychol.*, 1926, 1, 106–110.

disturbance. The limitations of detractors are similar to those of distractors. It is difficult to devise detractors which are constant in their effect and also take into account the previous experience and habits of attention of those used as subjects.

Phillip[1] devised a battery of attention tests especially for schoolroom use. His tests include variations in number span, mental multiplication and addition, alphabet and cancellation. The tests were given to 1,600 school children from ten to nineteen years of age and norms were computed for the several ages. The limits of growth appear to be reached at the age of fifteen years. The test may be used for diagnosing pupil ability and forming a basis for remedial work in the schools.

Easley[2] believes that all attention tests are based upon assumptions which have not been subjected to critical examination. On the basis of several attention and intelligence tests he undertook to determine whether attention tests correlated any more closely among themselves than they did with intelligence tests. His findings indicate that there is little, if any, relationship among the various tests of attention and that attention tests are no more closely related to each other than they are with tests of intelligence. This relationship is to be expected because of the fluctuation of attention and variations in the influence of distractors and detractors. Such variations would also produce low reliability and validity in attention tests themselves. Attention can be measured only in relation to the stimulus represented by the testing situation. The chief difficulty which confronts investigators who attempt to measure attention is that of making certain that the entire attention is focalized upon the stimulus studied. So far no test has been devised which adequately isolates and measures attention. However, lack of adequate measurement does not minimize the importance of attention in learning.

3. Range of Attention.—Two general methods of investigation have been used in studying the range of attention. The

[1] PHILLIP, R., The measurement of attention, *Cath. Univ. Amer. Stud. Psychol. & Psychiat.*, 1929, **2**, No. 1.

[2] EASLEY, H., An attempt to isolate the factor attention, *Amer. J. Psychol.*, 1931, **43**, 202–213.

simultaneous method consists in noting the number of objects (digits, dots, colors, etc.) which can be apprehended during a very brief exposure. The successive method consists in listing the number of consecutive stimuli (light, sound, etc.) which can be apprehended without counting.

Dallenbach and Gill[1] used the simultaneous method and asked subjects to state whether their impressions were one, two or more levels of clearness. They found both clear and unclear levels of consciousness in reporting range. They believe that the range of attention is much greater than has previously been supposed and that grouping of objects for increasing range is determined not only by arrangement of the stimuli but by the disposition of subjects. The range of attention of their subjects varied from approximately 17 to 42 objects.

Brown[2] studied the effect of homogeneous and heterogeneous stimuli upon the range of "unit" apprehension (or seeing the dots individually), "group" apprehension (or seeing them in special clusters) and "mediate" apprehension (or seeing the dots without system). Dots in yellow, blue, red and green Hering papers were pasted upon white cards. In some series the dots were homogeneous in quality and in others heterogeneous. The degrees of clearness were largest for mediate apprehension, medium for group apprehension and smallest for unit apprehension. The degree of clearness was largest for the homogeneous green, blue and red series, and smallest for the homogeneous yellow series and the heterogeneous series containing yellow. These results show that strong homogeneous colors tend to increase the range of attention because of their visibility, while light colors tend to reduce range. It follows that the more vivid the object, the greater the ease of apprehension and, consequently, the wider the range of attention.

[1] Dallenbach, K. M., and N. F. Gill, A preliminary study of the range of attention, *Amer. J. Psychol.*, 1926, 37, 247–256.

[2] Brown, A. F., The relation of heterogeneous and homogeneous chromatic stimuli in the range of visual apprehension experiment, *Amer. J. Psychol.*, 1929, 41, 577–594.

The successive method is illustrated by Gundlach, Rothschild and Young,[1] who measured the range of attention by means of 10 small electric lamps placed at equal intervals around the circumference of a circle and flashed at different rates. Accuracy of response to the flash stimuli varied with age, practice and speed of presentation. Oberly[2] used digits in studying range. The digits were read in a monotone with the exception of the last so that the subjects could know when a series was completed. He found that there was a close relationship between memory and attention spans.

When objects are familiar and of similar intensity, attention may range over a wide area and apprehension becomes a matter of course. When objects are unfamiliar or not clear, they demand a greater amount of concentration upon individual units, thus narrowing the range of attention and increasing its intensity in order that apprehension may be secured. In a group of familiar objects the eyes sweep the group and there is instantaneous apprehension. When there is one strange object in the midst of several familiar objects, attention will cover the group and immediately concentrate upon the unfamiliar object, often to the exclusion of those more familiar. The same is true of unclear objects in the midst of those which are clear.

The range of attention is narrow in children and under normal conditions increases with age and experience. The increase in range of attention is largely due to increased experience and familiarity with the objects of attention and to associations which have been formed. An adult unfamiliar with Chinese characters may have his attention diverted from them because of their lack of meaning, or, because of some interest, he may recognize these characters as a problem to be solved and concentrate upon them in units. A Chinaman may attend to several characters because of familiarity with them. Thus attention may cover a wide range. Age and experience furnish

[1] Gundlach, R., D. Rothschild, and P. T. Young, A test and analysis of "set," *J. Exper. Psychol.*, 1927, **10**, 247–280.

[2] Oberly, H. S., A comparison of the spans of attention and memory, *Amer. J. Psychol.*, 1928, **40**, 295–302.

the opportunity for the acquisition of meanings and the development of associations.

Intelligence is also a determining factor. The normal person may have a range of several digits while the subnormal individual may in extreme cases be unable to attend to more than one digit at a time and that with a small degree of apprehension. There are narrow-and broad-span types of attention. There is a type which is alert and active while other types are slow and sluggish. Individuals with narrow ranges of attention shift slowly from one object to another and are sometimes referred to as having "single track" minds. Such individuals are likely to be persistent, although slow, in the pursuit of an idea and to make judgments after more rapid thinkers have reached decisions and permitted the stimulus to slip back into obscurity because of attention to other stimuli. Individuals with wide ranges of attention form associations readily, make decisions quickly and pass from one stimulus to another with rapidity which is bewildering to the narrow-range observer.

Practice within limits increases the range of attention. These limits are set by innate ability, but few have their attention so trained that they can exert this limit. The range of attention for unassociated letters is narrow, but when these letters are grouped into words and words into sentences having meaning, the range of attention is increased. The range of attention may be increased by methods of grouping, by improved skill in observation, by increased experience and familiarity and by purposive effort.

4. Duration of Attention.—Attention is not a continuous process, but a series of pulsations varying in length according to the stimulus, the number of associations that may be formed and the purpose and interest of the individual. Billings,[1] in studying duration of attention, used as stimuli dots on paper, small parts of pictures, cutaneous stimuli of various sorts and the noise of buzzers. The subjects were required to press upon a key so long as the stimulus occupied the attention and to release it whenever it wandered. The subjects later were asked

[1] Billings, M. L., The duration of attention, *Psychol. Rev.*, 1914, **21**, 121–135.

to enumerate the objects they observed in the interval and to record the time during which attention was held. Duration of attention was only a little over 2 seconds. However, the duration of attention varied with the complexity of the stimuli. In the case of simple stimuli the duration was very short, whereas in complex stimuli attention was longer.

Gemelli and Galli[1] used a series of visual stimuli which were presented at a uniform rate. The subjects reacted by releasing a telegraph key according to prearrangement at the appearance of certain figures. Reactions were automatically recorded, and duration was measured by the length of time that the rate and accuracy of reaction remained constant. Every change in reaction was regarded as a fluctuation in attention. It was also found that the duration of attention was very short—an average of 1.752 ± 0.357 seconds.

Ritterhaus[2] used the cancellation test and assumed that variations in performance were due to fluctuation in attention. He found that the curves of performance represent two types of individuals. One type has a set for speed in which the time for cancellation was short and errors many, and the other has a set for accuracy in which the times were long and the errors few. This test has been used in detecting symptoms of certain mental diseases and in measuring fatigue.

It is possible to have what might be termed *prolonged attention* where the object is constantly changing or the manner of regarding it is changing, or where new associations are being formed. A book, a problem or a lecture holds attention because of the changing material presented for consideration. Distractions are avoided and attention is held until there is no further cause for interest. The mind remains constantly active and when the possibilities of a subject or topic are exhausted attention is quickly directed to other stimuli. Angell[3] says:

[1] GEMELLI, A., and A. GALLI, Ricerche sull attenzione, nota prima un nuova metodo perto studio delle oscilazione dell attenzione, *Arch. ital. di psicol.*, 1920, 1, 39–56.

[2] RITTERHAUS, E., Die Untersuchung der Aufmerksamkeitsschwankungen und ihre diagnostiche Bedeutung, *Arch. f Psychiat. U. Nervenkr.*, 1925, **75**, 585–630.

[3] ANGELL, J. R., *Psychology*, New York, Holt, 1908.

Thought processes which cease to move cease to exist. They simply go out. To keep a thought alive we must keep turning it over, keep doing something with it. . . . What we call attention to a topic for a considerable period of time, will therefore, always be found to consist in attending to changing phases of the subject, the ideas associated with it.

Attention is held in the classroom by regularly varying methods of presentation so that the topic or problem is seen in its various phases and relationships.

5. Some Factors Which Influence Attention.—Attention is a process of selecting the stimulus to which reaction will be made. The law of selection assumes that at a given instance the mind can attend to only one stimulus. This process of selection or the determination of the stimulus to which response will be given is influenced by several factors including (*a*) change, (*b*) intensity and striking quality, (*c*) distance from point of fixation, (*d*) definite form or outline and (*e*) training.

a. Change.—Advertisers have long recognized the strength of change in attracting attention as noted by the daily or periodical changes in advertisements, window decorations, posters and flash signs. Wilcocks[1] measured the effect of change upon attention by accuracy of report. He unexpectedly changed one member of a stimulus series, one member being suddenly moved, or one remaining stationary while all others were moved. His experiments showed a marked increase in memory for heterogeneous content which was unexpectedly introduced among otherwise homogeneous material. Wilcocks also noted the effect of changes in loud noises during the performance of simple operations and found that attention was attracted to a change in the sound, whether cessation of sound or increase in its intensity. He also found that by inserting changes in colors unexpectedly the reaction time was sometimes lengthened and at other times shortened. The more monotonous the stimulus becomes, the more attention wanders, while any change from the habitual tends to attract and hold attention. Attention in the classroom is prolonged either by changing the material or treating the same material in a different manner.

[1] Wilcocks, *op. cit.*

b. Intensity and Striking Quality.—A sudden or unexpected loud noise or a bright light attracts attention regardless of the incentive used to hold attention to the task at hand. Likewise a large object is more likely to attract attention than a small one. It is probable that size is an important factor in attracting attention in the case of visible objects. Dewey and Dallenbach[1] show that size is a condition of clearness and a determinant of attention. Black headlines are more attractive than light headlines in advertising and journalism. Posters in bright colors attract attention more readily than do posters in black and white and small-sized letters. The teacher may use intensity by emphasizing the salient parts of a course or assignment. She can also intensify attention by making diagrams and outlines on the blackboard.

c. Distance from Point of Fixation.—Stimulus objects near the point of fixation have a higher value for attention than those further removed. Friedline and Dallenbach[2] used two stimulus objects alike in every respect except distance. The value of attention for different distances was determined by the intensity with which the objects were reported as clear. They found that stimulus objects near the point of fixation had a higher value of attention than those further removed. The inference is clear that the farther a stimulus is removed from the center of focus of attention, the less the impression made upon the mind. All materials presented in the classrooms should be within the range of pupil comprehension.

d. Definite Form or Outline.—Visual stimuli having form have greater power of attracting attention[3] than formless stimuli of equal or less intensity. The essential condition for clearness of outline is that the stimulus shall differ distinctly from its background. When the difference in intensity between the

[1] DEWEY, D., and K. M. DALLENBACH, Size *vs* intensity as a determinant of attention, *Amer. J. Psychol.*, 1924, **35**, 121–125.

[2] FRIEDLINE, C. L., and K. M. DALLENBACH, Distance from point of fixation *versus* intensity as a determinant of attention, *Amer. J. Psychol.*, 1929, 41, 464–468.

[3] MEADS, L. G., Form *vs.* intensity as determinants of attention, *Amer. J. Psychol.*, 1915, **26**, 151–152.

stimulus and background is large, the degree of attention is high. Woodrow[1] used two visual stimuli of the same objective intensity, one being a definitely outlined square and the other a formless blot. The change in intensity was produced at the source of illumination and it was noted that the difference in clearness between the square and the blot was more pronounced with increased intensity of light. With increase in size of objects the effect of outline became less important. Woodrow concluded that the greater clearness of change in the square was due not to the effect of the contrast upon the intensity of the square but to the definiteness of outline. It is, however, possible that the purpose of concentrated attention is to make the outline more definite.

Thus, both definiteness and indefiniteness of outline may serve under varying conditions as factors in attention. Involuntary attention is probably more readily attracted by definite form while voluntary attention tends to center upon the vague or ill-defined. Teachers should present important features and topics so that they stand out from those that are subordinate. Attention may be enhanced by systematically outlining materials, by specific assignments and by the establishment of definite objectives.

e. Training in Attention.—The ability to give sustained concentration is an attitude of attention which is developed by habitual application to definite tasks. Evans[2] says:

> To attend well means ability to ignore nonessentials for the sake of the essentials. The essentials have been brought to the front by the development of certain valuable habits. The development of these habits has been in opposition to the influences of distraction. The subject has acquired certain adjustments to the constant conditions of his work. Useless reactions have been repressed early in the practice period. With this ability to ignore the nonessential stimuli comes a certain feeling of self-confidence and self-reliance which stimulates the subject to active interest in the work.

[1] Woodrow, H., Outline as a condition of attention, *J. Exper. Psychol.*, 1916, 1, 23–29.

[2] Evans, J. E., The effect of distraction on reaction time, *Arch. Psychol.*, 1915–1917, 5, No. 37.

Pupils who have not habituated themselves to prolonged and concentrated attention to their studies become vacillating, progress slowly and may even become problem cases in school. Habits of attention may be developed through practice and effort. Forced concentration by means of repetition and automatization may later lead to spontaneous attention.

B. Interest

Interest is an emotional attitude toward a stimulus which produces a desire for a continuation of attention toward that stimulus. Interest plays a significant part in the selection of stimuli to which attention is given, although attention may be forced when interest is absent. The greater the interest, the less the effort necessary for directing attention. Interest determines which stimuli shall enter the focus of consciousness and the duration of such focalization. It is the unifying element in attention which builds up associations, determines sequences and selects their order of importance.

Interest may be either extrinsic or intrinsic. Extrinsic interest is interest in related or associated factors. A pupil's interest in a subject is sometimes due not to interest in the subject itself, but to interest in his teacher. This is particularly true among pupils in the lower grades where the personality of the teacher has more influence than does the subject matter itself. Extrinsic interest is often manifested in the case of some subjects in which the pupil is interested only as a means of fulfilling requirements. In such cases there is not sufficient interest to make a permanent impression and as soon as the stimulus is removed interest ceases unless there is some continued incentive. Extrinsic interest is chiefly artificial.

Intrinsic interest is seldom spontaneous and develops only after familiarity with the stimulus. The natural curiosity of children may express itself in various ways according to the environment. Children who are reared in agricultural communities are usually interested in the occupations and activities of farming. Interests may be directed in many ways and may be changed by circumstances. Intrinsic interest is cumulative.

The pupil who has a real interest in geology is not satisfied in knowing only the geology of his immediate environment but wishes to extend his knowledge. Although other interests may intervene, the attention will return of its own volition to the subject in which it is centered. Such interest is not lost because attention is attracted elsewhere but may return at unexpected moments with little stimulation while extrinsic interest once lost is difficult to regain.

Interest may have a natural basis in the environment of the child or it may be stimulated by artificial means. The work of the classroom is often a case of artificial stimulation of interest in material for which the child has little background for natural development. In such a case, artificial interests should be developed until a genuine interest has been aroused.

When attention is attracted it is immediately diverted by other stimuli unless there is something to retain it. It is either held by effort of will or by interest. Attention may be attracted without interest, but interest cannot be aroused without attention. Interest is the stabilizing agent in attention, which holds it fixedly to its course until impressions are received and mental records are made.

C. How to Attract Attention and Develop Interest

Teachers are interested in how to attract attention and how to hold it once it has been attracted. Holding attention is by far the more difficult problem because it is dependent upon the amount of interest that may be aroused either in the task at hand or in the results to be achieved.

1. Interest is dependent upon the complexity of the stimulus.[1] When the stimulus affords opportunity for many associations, attention is of relatively long duration. Interest is dependent upon the complexity of the attention process. When the stimulus offers possibilities for meanings and is of sufficient perplexity and difficulty to arouse curiosity, interest

[1] This and the following principles are adapted from H. F. Adams, An extension of Pillsbury's theory of attention and interest, *Psychol. Rev.*, 1923, **30**, 20–35.

is easily gained. The puzzle is interesting because it offers an intriguing stimulus and one is eager to determine its outcome by solving it. This principle assumes that to stimulate interest the problems of the classroom must be real, intriguing problems for pupils. If problems are too easy or too difficult, initiative and interest are lost. Problems should, therefore, be within the ability of pupils so that they may be stimulated by success.

2. **Interest is dependent upon the association of old and new experiences.** Interest is aroused by using the pupil's past experience as a basis upon which to build new experiences. Adams presented a picture to a group of students four different times. He found that the students noticed the picture less frequently at each successive presentation and that the most decided decline in observation occurred after the first appearance of the picture. His study shows that the new must constantly be changing or it will cease to have the appeal of newness. However, as Adams points out, relating the old to the new is effective only when the old has been pleasant.

This principle is important in preparing pupils for new courses and assignments. Interest in new courses is best aroused when the teacher shows how the new course is related to previous courses or explains that new assignments are extensions or other phases of those already covered. Civics courses become interesting when pupils realize that the topics discussed are similar to problems of everyday life and there is an attempt to relate them. Arithmetic is interesting when it deals with problems with which pupils are already familiar. After attention is attracted it is necessary to vary the procedure in order to hold it. New aspects of the same topic increase interest and hold attention. Methods of presentation should be changed and new aspects of learning material should regularly be introduced and associated with the old. New material should be added to old material or new aspects of the old developed in order that attention may continue.

3. **Congruity and expectancy intensify interest.** This principle has two forms. The first form exists when the mind selects incoming impressions which are congruous with it. The

second form exists when there is for the moment no congruity between incoming impressions and the individual's mental set.

Teachers often believe that the novelty of textbooks, lectures and discussions is sufficient to create interest on the part of the pupil. If interest is developed it is likely to result from voluntary attention. Novel materials may coincide with the past experience and attitude of the pupil, but bringing the pupil and the subject matter together is usually a random process. A goal should be established and a plan developed by means of which the pupil will react to subject matter in terms of his own past experience and attitude.

The second form of the principle illustrates the need of preperception, which assumes that the mind must be prepared for that which it is to experience. A short synopsis of a book, a story or play, giving some of the appealing sections with suggestions as to what may be observed, creates an attitude of expectancy and attracts attention to the important features. This principle is observed in the reviews of articles and books and in catalogues which give general descriptions of courses. Individuals attend shows with certain ideas as to what they expect to see. These preconceived ideas are developed by means of colored posters, pictures, striking headlines and previews. Appeals may be made to pupils by outlining the material of the next assignment, wherein the important features and problems are indicated, or by relating the next assignment to the previously acquired information of the pupil. Preperception is essentially a process of intellectually preparing pupils for their observations so that the mind will be in a state of readiness to receive incoming impressions.

4. **Future implications arouse interest.** Munsterberg[1] studied tasks which might be considered monotonous. He cites the case of a woman who had been packing electric lamp bulbs in a factory for many years. It would be supposed that the work was boring. On the contrary he states that this woman was interested in determining how many bulbs she might

[1] Adams, *op. cit.*

pack during the next pause. She was interested not so much in the packing of light bulbs as in the outcome of her own efforts. Kitson found that advertising which pertained to uses of goods advertised was more effective than that which dealt with processes of manufacture, personnel of firm and sources of raw material. Uses of goods signify future implication and are therefore more interesting.

Advertisements appeal to success, achievement, romance and luxury. The lack of these represents present conditions which are both unpleasant and uninteresting. Insurance companies suggest the importance of life insurance by making an appeal to travel, security, ambition, accomplishment and support in old age. Advertisers realize the value of associating sales products with desires or needs, and their advertisements are intended to stimulate interest in the product by means of these associations. The automobile dealer appeals to desires for luxury, pleasure and economy. Food products appeal to the appetite and advertisements attempt to create desires for specific brands. The success of these advertisements depends upon their appeals to either necessity or desires which eventually may be satisfied. Lecturers inspire success, ministers appeal to wholesome living, and any person who expects to lead makes an appeal to positive and constructive thinking. Successful teachers inspire their students to higher achievement in school and life.

5. Both immediate and remote ends enhance interest. Ends are goals of achievement while means are the procedures necessary to reach the ends. The pupil is more likely to be interested in the completion of a course of study and the rewards accompanying it than he is in the means of their attainment, more interested in a future vocation than in the stages of preparation leading to it. Likewise he is more interested in the solution of a problem than in the steps used in reaching the solution.

Interest is more directly attached to immediate ends than remote ends. That which is remote in time and space cannot easily seize upon the imagination of young children. To

furnish incentive, immediate ends should be emphasized. It is not sufficient for the young pupil to imagine himself successful when he reaches maturity. He must have the constant stimulus of achievement at every stage in his educational program. The younger the pupil, the greater the need for using immediate objectives. With older pupils ends may be more idealistic and further removed, but even here the immediate ends are more impelling.

The provision in school for immediate and remote ends is primarily a matter of adapting incentives. Incentives in the classroom may bring immediate rewards, as in knowledge of progress, encouragement and individual prizes provided at regular intervals, or they may be in the form of remote graduation or even more remote achievement of a desired position, as in completing certain subjects because they assist in realizing an ambition. If remote ends are used, they should be complemented by immediate ends so that the pupil may be conscious of accomplishing definite objectives during various parts of the school year in addition to the ultimate goal of successfully completing a course or entering a vocation. Every subject provides an opportunity for incentives, and both immediate and remote ends should be used.

6. Attention and Interest Vary among Individuals. Munsterberg found some persons who were interested in most monotonous tasks. He also found that the majority of his students appeared to have stronger impressions of varying stimuli than of those which were largely uniform. His work illustrates the law of individual differences in attention and interest. Any stimulus may attract attention and interest of someone at some time. The attraction is influenced by such factors as need, desire, associations and attitude. Since these factors are constantly changing, the power of the stimulus to attract and hold attention also changes. An appeal to attention and interest may be made in the classroom by developing favorable attitudes toward subject matter and the school environment, and by associating learning materials with the desires and needs of individual pupils. Students should be shown

by the results of experimentation[1] the beneficial effects of maintaining a favorable attitude toward their work and success. When favorable attitudes are developed, pupils are better able to perform the work that the school requires.

D. Summary

Attention is the focalization of consciousness upon stimuli and is an essential requirement for learning. The school is not concerned so much in causing pupils to attend as it is in directing their attention upon specific tasks. In investigating attention some means of dividing or reducing attention are usually employed. It is assumed that during periods of concentration the individual is performing at capacity rate and any deviation in performance caused by distractors or detractors marks the degree of attention. Reaction time, errors, omissions, rate of learning and amount of recall may be used as a basis of measurement. Teachers may measure attention by noting general attitudes of pupils, frequency and type of questions and the quality and amount of notes taken during recitation.

Range of attention is measured by noting the number of stimuli that may be apprehended when simultaneously or successively presented. The degree of range is largely dependent upon familiarity with the stimuli. Range of attention is increased by methods of grouping, by improvement in observation and by increased familiarity with the stimuli of attention. Attention constantly fluctuates and when directed to a specific stimulus is of very short duration. What may be termed *prolonged attention* is usually reaction to a meaningful or changing stimulus. Prolonged attention may be produced by varying the method of presentation or the material presented. Attention is influenced by several factors including change, intensity and striking quality, distance from point of fixation, definiteness of outline and training.

The school is interested both in how to attract attention to specific tasks and in holding it when it is attracted. Interest

[1] Book, W. F., How to develop an interest in one's task and work, *J. Educ. Psychol.*, 1927, 18, 1–10.

assists both in directing and in sustaining attention. Interest is dependent upon the extent to which the stimulus affords possibilities for meanings and associations. It is also influenced by the degree to which old and new experiences are brought together in consciousness. Attitudes of expectancy aid pupils in receiving incoming impressions. Future implications when positive and pleasant inspire pupils to higher achievement. Both immediate and remote ends are effective but immediate ends are more impelling. Since the power of the stimulus to attract attention varies, interest is influenced by the individual to whom the stimulus is presented.

CHAPTER XIV

GUIDANCE TECHNIQUES

Guidance consists in instructing and directing pupils in the process of reaching a definite objective; in a sense, it, *is* teaching. Techniques of guidance have naturally always been used in the school, but there has been comparatively little scientific investigation to test their effectiveness. Early investigations dealt mainly with the study of animals. Thorndike[1] found that cats which had been caused to enter a box preparatory to obtaining food soon learned to go through that procedure at every feeding time while those which were dropped through a hole in the top of the box never learned the reaction of entering the hole as a means of obtaining food. Cole[2] found that raccoons learned to enter boxes into which they had formerly been lifted, that they learned to undo a fastening by being put through the act and that they repeatedly learned different acts by physically being put through them when they had not been able to learn by other methods. Yerkes[3] employed guidance in his studies with dancing mice. His experiments dealt with the sight, sound and tactual learning of mice in the dark and light and ability to choose properly between black and white. While in these studies the element of guidance was incidental to the purposes of the experiments, they represent the earliest scientific studies in this field.

A. Techniques of Guidance

There are two general techniques for administering guidance in the learning situation. These techniques may roughly be

[1] Thorndike, E. L., Animal intelligence: An experimental study of the associative process in animals, *Psychol. Rev. Monog.*, 1898, 2, No. 8.

[2] Cole, L. W., Concerning the intelligence of raccoons, *J. Comp. Neur. & Psychol.*, 1907, 17, 211–219.

[3] Yerkes, R. N., *The Dancing Mouse*, New York, Macmillan, 1907.

classified as guidance by physical means and guidance by intellectual means. Each technique affords a different psychological approach and the effectiveness of each varies with the learning situation in which it is employed.

1. **Guidance by Physical Means.**—Guidance by physical means was the first technique to attract the attention of the experimenter. Owing to its simplicity of administration, it is the most adaptable technique for use with young children who are incapable of following instructions given by verbal or other means. The technique includes two devices: (*a*) putting the subject through the act by manual means and (*b*) guiding the subject through the act by mechanical means.

a. Putting the Subject through the Act by Manual Means.—Putting the subject through the act by manual means was the earliest form of guidance studied with animals. Thorndike and Cole used this technique in their study with cats and raccoons. Ludgate[1] has also employed it in studying the maze learning of human beings. The experimenter guided the hand of individuals through the act of tracing the maze and individuals so guided were more proficient in learning than unguided learners. When this plan is used in teaching handwriting, the teacher guides the hand of the child in making lines or letters until correct responses are produced. However, guidance by this means tends to develop dependence upon the teacher which, when withdrawn, makes adjustment difficult. The device may be employed where the age and maturity of the learner are not sufficiently developed to permit the use of other means. It may advantageously be used in teaching some types of motor skills where attention is directed to inaccuracies of movement or position.

b. Guiding the Subject by Mechanical Means.—Guidance by putting the subject through the act implies the use of a human agency in the prevention of errors, while mechanical guidance is accomplished by means of an inflexible and inanimate device which restricts the reactions of the learner to the precise

[1] LUDGATE, KATHERINE E., The effect of manual guidance upon maze learning, *Psychol. Rev. Monog.*, 1924, **33**, No. 148.

responses that are essential for learning the task. An example of this device is a maze so constructed that the blind paths are blocked by invisible partitions and the subjects are taught to run the true path without opportunity of committing errors. Koch[1] thus trained human subjects by the use of a stylus maze in which the false paths were blocked by invisible stops which prevented the commission of errors during the guided trials.

Some attempts have been made to use mechanical guidance in teaching writing and drawing.[2] Stencils, sandpaper outlines, tracing paper and grooved blocks have been employed, and by using these devices the child traces the outlines with finger or pencil. Tracing letters involves some of the principles of writing, but establishes irrelevant habits which must be broken when one begins to write.[3] Guidance by mechanical means tends to cause the learner to develop dependence upon the mechanical device rather than upon his own resources. Its chief advantage is in guiding very young children or those of inferior intelligence who cannot follow other means of instruction.

2. Guidance by Intellectual Means.—Guidance by intellectual means presupposes that the individual use his own initiative in response to verbal guidance given by the teacher. The technique embraces (*a*) explanation and direction, (*b*) supplying the rule, (*c*) directing attention, (*d*) information of success and error and (*e*) visual representation.

a. Explanation and Direction.—Guidance by explanation and direction is one of the most common devices used in teaching. Wang[4] studied the use of verbal guidance in an experiment in motor learning. His subjects were verbally directed through a

[1] KOCH, HELEN L., The influence of mechanical guidance upon maze learning, *Psychol. Rev. Monog.*, 1923, 32, No. 147.

[2] GATES, ARTHUR, and G. A. TAYLOR, Acquisition of motor control in writing by pre-school children, *Teach. Coll. Rec.*, 1923, 24, 459–468.

[3] HERTZBERG, O. E., Comparative study of different methods of teaching beginners to write, *Teach. Coll. Contrib. Educ.*, 1926, No. 214.

[4] WANG, T. L., The influence of tuition in the acquisition of skill, *Psychol. Rev. Monog.*, 1925, 34, No. 154.

maze for a given number of times, varying according to the group being tested. He found that verbal guidance given during the initial stages of learning was most effective and the subjects so guided were superior to the unguided group in learning the maze. Most directions are accompanied by explanations in order that the various parts of the instruction may be made clear. The method of explanation and direction is one of the most valuable devices because it can be adapted to individual needs and repeated in various ways until the learner has a thorough comprehension of every part of the process. It is probable that no other form of guidance is complete unless accompanied by explanation and direction. Verbal guidance may be administered at any time as a means of preventing errors, but there is possibility of overdoing it, making the explanations so simple and the directions so explicit that the pupil's initiative is thwarted and a feeling of boredom developed.

b. Supplying the Rule.—Waters[1] supplied the rule in the solution of a problem which consisted in drawing from a string of beads in such a manner that the subject was able to draw the last bead on the string. Directions were given as follows: (1) "Always draw so as to leave a multiple of three; (2) always draw so as to leave the sum of the highest and lowest possible draws; (3) the solution of the problem depends upon your leaving the number of beads exactly divisible by the sum of the highest and lowest possible draws." The statement of the principle produced better learning in the first, as well as subsequent, problems, and the short and concise statement was most beneficial.

Although knowledge of the principle is important, it is to be noted that in Waters's experiment it did not produce immediate success. It was necessary for the learner to explore the mechanism of the problem and to develop an understanding of the principle. Concrete principles are of greater importance than abstractions which may easily be memorized and reproduced through tests. Teachers sometimes assume that teach-

[1] WATERS, R. H., The influence of tuition upon ideational learning, *Gen. Psychol.*, 1928, 1, 534–549.

ing is completed when the child learns rules, even though they are not understood. Rules should always be interpreted and given immediate application. If the class period is devoted to learning rules rather than to their development and application, it may defeat its own purpose. Rules are most effective when they result from the pupil's own development of methods and generalizations.

c. Directing Attention.—Directing attention differs from supplying the rule in that the pupil is not given the principle involved in performing a task but rather his attention is directed so that he may be able to make his own generalizations. In short, guided attention more nearly approaches the method of inductive teaching, while giving the rule is typical of the process of deduction.

In Waters's[1] experiment one of the groups learned to solve the problem by having its attention directed to the significant element in the solution, which was the number of beads remaining on the string. This result was achieved by having the subjects call the number of the remaining beads on the string, which cue proved effective in learning to solve both immediate and subsequent problems. Reeder[2] applied this plan to the teaching of geography and conducted an experiment to compare its effectiveness with that of the ordinary textbook method of teaching. He found that by the use of pivotal questions superior results were obtained over the textbook method. He attributed the superiority of this method to specific questions which stimulated pupils to see relationships in the material and to deduce principles for themselves.

Directing attention is also useful in teaching spelling. The failure to perceive clearly the letters of a word is a primary cause of spelling difficulty. If the confusing letters of a word are emphasized so that attention is focused upon them the difficulty may be partially overcome. One of the purposes of all assignments is to direct attention to significant elements of

[1] WATERS, *op. cit.*

[2] REEDER, EDWIN H., A method of directing children's study of geography, *Teach. Coll. Contrib. Educ.*, 1925, No. 193.

the lesson in order that interest may be aroused and errors prevented.

d. Information of Success and Error.—The commission of errors is to be expected, but by directing attention to them their number may be reduced. Waters[1] found a high degree of efficiency with the error device of guidance. In his experiments the subject was informed of his error immediately upon its occurrence, and was forced to correct it at once. Although the subject readily learned by this method, the learning did not transfer to other situations. Wang[2] provided information of errors in three ways: (1) a signal was given at the inception of the errors; (2) the subject was informed of the completion of each error; and (3) the subject was informed of the nature of the error upon its completion. In some cases the first method was superior to the others. When information of the error is given at its inception, it permits the learner to correct it immediately; after one has become conscious of the correction, the error is likely to be inhibited in the future. Although each method proved beneficial, the procedure of giving complete information was most valuable. Guidance is most effective when it reveals accomplishment in a detailed and diagnostic manner.

e. Visual Representation.—Visual representation includes both demonstration and visual aids. In some subjects a demonstration given at the appropriate time affords a clear conception of the form the learner's activity should take. The demonstration not only clarifies the mind of the learner but provides inspiration to achieve and stimulates the impulse to excel. In acquiring skills which require delicate coordinations, a demonstration that reveals all the elements involved in the act is effective. Unless the demonstration reveals all pertinent elements with precision, its efficiency is impaired and may produce a state of confusion in the learner.

Although demonstration is effective in performing acts of skill, it has limitations in learning situations which involve ideas and abstractions. Waters[1] used the demonstration

[1] WATERS, *op. cit.*
[2] WANG, *op. cit.*

technique to illustrate the process of solving a problem based upon an arithmetical principle. In this study he concluded that the demonstration method of guidance definitely proved a hindrance in the solution of a problem. In problems there are phases of the procedure that cannot be revealed in a demonstration alone, which no doubt accounts for the difference between its effectiveness in situations involving skill and those involving ideas. Demonstrations in ideational situations should be accompanied by adequate explanations and directions.

Charts and diagrams are common devices in the teaching of science and mechanics. A pertinent example of visual aids is given by Carr,[1] who measured the effectiveness of the use of a map in the solution of a maze problem. The subjects were given three types of maps to be learned as follows: (1) a map which showed no stop in the maze; (2) one which showed the maze and the true path of the solution; and (3) a map of the true path only. His results show that the more information given on the map, the more effective was the guidance in the solution of the maze. One guided trial by the second method (complete information) was equivalent to 2.64 unguided trials. The use of diagrams, slides and motion pictures is based upon principles involved in this device. The learner, by such means, is enabled to see various parts of the learning situation in their relationships. In all types of learning which involve understanding of complicated or intricate combinations, visual aids are of direct value.

3. Evaluation of Guidance Techniques.—Each type of guidance has its peculiar merits and limitations. Figure 19 shows the relative efficiency of the two general techniques. This figure, which is based upon composite treatment of a large number of studies, indicates that guidance by intellectual means is more effective than that by physical means. It should be noted, however, that one type of guidance may be of greater value in one learning situation than in another. This does not mean that one technique has low value, but it does

[1] Carr, Harvey, The influence of visual guidance on maze learning, *J. Comp. Psychol.*, 1921, 4, 399–417.

indicate that in some learning situations another type would have been more efficient.

Frequently there are situations in which it is possible to use a combination of guidance devices. For example, the pupil may be shown a diagram, given a demonstration or an explanation and stimulated by questions as a means of guiding him in the performance of a task. The order of procedure for the administration of guidance may include the following steps: (1) directing attention; (2) demonstration; (3) explanation;

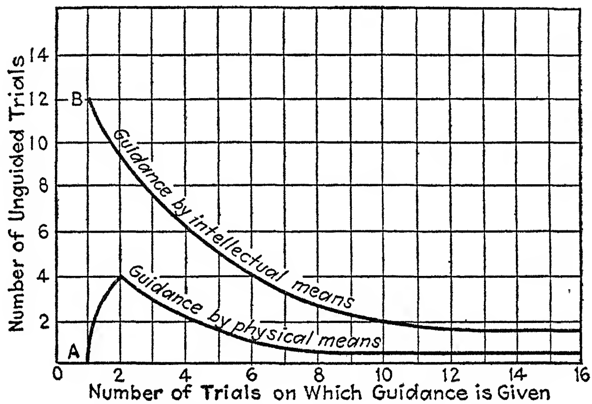


FIG. 19.—The relative effectiveness of the two major types of guidance in learning. These curves represent the number of unguided trials required to equal one guided trial. (*Curves developed on the basis of data compiled by Carr*, 1930.)

(4) pupil's attempt; (5) correcting errors, followed by further demonstration and explanation as needed. Excess guidance may thwart the pupil's initiative and produce inability to cope with situations when guidance has been removed. Guidance should always reenforce and develop initiative of the pupil.

The greatest usefulness of all guidance techniques is in the prevention of errors. Approximately the same number of trials is needed in a guided task as in one that is unguided. The learner may make as many trials in a guided task as in an unguided one, but he commits fewer errors. In the element of trials or final speed guidance for error prevention may retard the learner's speed by causing the learner to become excessively

cautious. Although guidance may be detrimental when speed alone is considered, it results in a degree of accuracy that cannot be approached by the unguided learner. Table 33 is typical of the effects of guidance on trials, errors and final speed in learning a finger maze. Guidance is effective in reducing the number of errors, but it has the greatest influence on the final running of the maze. When appropriate techniques are used, learning efficiency will be increased in both speed and accuracy.

TABLE 33.—PERCENTAGES OF SAVING DUE TO A KNOWLEDGE OF ERRORS (After Wang, 1925)

Groups	Trials, per cent	Errors, per cent		Final speed, per cent
		Retracing	Blind	
N				
A	29.65	57.27	46.43	− 72.01
B	21.25	69.28	58.03	− 62.77
C	32.62	73.14	69.64	−100.00

N = normal group in which no guidance was given. A, B and C = three modes of giving information (A = counting at the completion of each error; B = counting at the point of making each error; C = naming each error after it was made).

Although it is possible to deduce general principles regarding the effectiveness of guidance techniques, their efficiency varies with the type of learning situation in which they are used. In the acquisition of motor skills it is desirable that the learner acquire a set of automatic responses which will recur without conscious effort. It is also essential that these habits be developed as quickly and effectively as possible, and it is of especial importance that the learner be prevented from developing errors which later will have to be unlearned. This condition is facilitated by (1) a clear conception of the meaning of the act; (2) knowledge of the exact composition of the act; and (3) a measure of achievement which indicates the degree of success attained. Ewert and Lambert[1] found that the more complete the instruction in stylus maze learning, the more accurate the

[1] EWERT, P. H., and J. F. LAMBERT, The effects of verbal instruction upon stylus maze learning, *Gen. Psychol.*, 1932, 6, 377–399.

paths seemed to be. The elements of the act should be determined with a high degree of exactness in order that guidance may be given economically. Children may learn a perfect form of writing, only to find that form alone is worthless when it becomes necessary to write both rapidly and legibly. Guidance given in motor skills should provide specific drills for all elements that compose the act.

The assignment in schoolroom situations furnishes an excellent medium through which guidance may be given. The assignment should be clearly given so that the pupil may know what is expected, the method of study most efficient for the material and such other information, demonstration, explanation and direction as will permit maximum efficiency with minimum effort. The nature of the material to be learned and the kind of results desired by the teacher should be considered. The assignment should not only clearly indicate what is to be done and the method of doing it, but should motivate the pupil to exert his best efforts.

Guidance plays an important part in the solution of problems. Unless the method of solution is emphasized, the learner is likely to stumble along the path of trial and error, and profit little by his own experience. Guidance in the technique of reasoning should so be given that the pupil is unconscious of a directing force. The solution of the problem should be the result of the pupil's own effort, even though the teacher has directed the activity. In such procedure direction of attention by a series of pivotal and pertinent questions is usually effective. Without guidance problem solving of the child is likely to result in loss of confidence and initiative.

B. When to Give Guidance

Guidance is most effective when given at definite stages in the learning process. There are three general positions for its interpolation: (1) during the initial stages of learning; (2) at one or more points in the learning situation after the learner has had opportunity to make several unguided attempts; and (3) a combination of these methods

Alonzo[1] concluded that initial guidance is less effective than guidance given later in the process. Ludgate[2] found that guidance interpolated early in the process of learning was most beneficial. Meek[3] believes that the ideal situation is from two to five initial guided trials and that there should be an interval of 24 hours between them. Waters[4] believes that guidance is most effective when it is given at the beginning of the problem. Wang[5] also concluded that verbal guidance, when given during initial stages of learning, is most beneficial. Guidance should be given during the initial stages of learning and there should be continued guidance when needed as the learner proceeds with the task. The time and place for the administration of guidance are dependent upon the kind of task, the type of guidance and the particular needs of the learner.

C. Amount of Guidance Needed

There is a point in every learning situation beyond which additional guidance rapidly diminishes in effectiveness. It may be expected that the point of diminishing returns will vary with individual learners and the type of learning situation. It is essential that this critical point be established because over-guidance defeats its own purpose. When it is clear that the learner has mastered the salient points in the learning task so that his reactions are so firmly established that occasional errors will not result in the establishment of undesirable reactions, guidance may be withdrawn.

D. The Importance of Preventing Errors

The prevention of errors is most effectively accomplished by administering guidance during the initial stages of the learning

[1] Alonzo, A. S., The influence of manual guidance upon maze learning, *J. Comp. Psychol.*, 1926, 6, 143–158.

[2] Ludgate, *op. cit.*

[3] Meek, Lois, Learning and retention of young children, *Teach. Coll. Contrib. Educ.*, 1925, No. 164.

[4] Waters, *op. cit.*

[5] Wang, *op. cit.*

process. Peterson[1] found that errors are eliminated in reverse order of the way they occurred in the learning process. Kuo[2] found that the most crucial errors were eliminated first. Alonzo believes that the learning of errors is unnecessary and that, if they are prevented in the initial stages of learning, there is little likelihood of their occurrence during the later stages.

Since the learning of errors is influenced by the law of frequency, it is clear that each time an error is repeated the tendency to continue to repeat it is increased. If desirable responses are frequently made, they become fixed and there is slight probability of other responses being elicited. Myers[3] believes that reaching of correct answers contributes more to efficiency in learning than the detection of errors. It is probable that in the solution of problems the possibility of developing undesirable habits is not so great because of consciousness of principles at each stage of learning. In the solution of Waters's[4] bead problem, the learner is not confronted with an habitual situation. Each new stage in the problem requires constant readjustment which makes the development of habitual responses undesirable. There should be enough guidance to insure success, but error prevention should not be extended beyond that point in the solution of problems.

E. Some Principles of Guidance

1. Guidance should be administered before the learner has had opportunity to learn errors. In so far as the learner commits errors and is conscious of their occurrence, they are not likely to become detrimental. The distinction should, therefore, be made between committing errors, and allowing them to become a part of the learner's behavior pattern. If the learning of errors is prevented, there is no necessity for unlearning erro-

[1] Peterson, J., Backward elimination of errors in mental maze learning, *J. Exper. Psychol.*, 1920, **3**, 257–280.

[2] Kuo, Z. Y., The nature of unsuccessful acts and their order of elimination in animal learning, *J. Comp. Psychol.*, 1922, **2**, 1–27.

[3] Myers, G. C. and C. E., Finding mistakes *vs.* correct associations in simple number learning, *J. Educ. Res.*, 1928, **18**, 25–31.

[4] Waters, *op. cit.*

neous responses. Guidance should be continued until the learner has such control over his task that the commission of errors will not result in their becoming habitual responses.

2. **Guidance should so be administered that the learner's initiative will not be thwarted.** The pupil should be encouraged to exert his own initiative and should be trained to rely upon his own judgment in the performance of tasks. The purpose of guidance should be to enhance the initiative of the learner rather than to develop dependence upon the teacher.

3. **The effectiveness of guidance is determined by the ability of pupils to perform both similar and new tasks on their own initiative and judgment.** Unless the pupil is able to solve new tasks without the assistance of the teacher, guidance originally administered is of limited value. The pupil after having received guidance should be able to make his own adjustments when unguided.

4. **Guidance is most effective when old and new experiences are brought together in consciousness.** The teacher by skillful questioning may lead the pupil to arrive at a conclusion by his own intellectual efforts. This may be accomplished by correlating old and new material.

5. **Guidance should be adapted to the character of the learning situation.** Since learning situations differ, much flexibility should be allowed in the administration of guidance techniques. In teaching the acquisition of skill, manual devices, demonstrations and visual aids are usually appropriate. In performing tasks of an ideational character, the intellectual forms of guidance are generally proficient.

6. **Guidance should be adapted to the age and intellectual maturity of pupils.** Young and dull children not only require more guidance but different techniques from older and brighter children. Since bright children comprehend principles more readily than do those who are dull, care should be exercised in the case of heterogeneous groups to recognize all levels of ability and maturity in the administration of guidance. Guidance by physical means is more efficient in the case of young and immature pupils, while guidance through

intellectual means may be used to greater advantage as children become more mature.

F. Summary

Guidance consists in directing achievement toward a definite objective. Guidance techniques may consist in directing the learner by either physical or intellectual means. Guidance by physical means includes directing the pupil through the act by manual means or mechanical means. Guidance by intellectual means includes: (1) explanation and direction, (2) supplying the rule, (3) directing attention, (4) information of success and error and (5) visual representation. These devices afford different psychological approaches and their effectiveness is dependent upon the nature of the task and the needs of the individual learner.

Guidance by physical means may be used to advantage in teaching young, dull or immature pupils in situations involving motor skills, but its effectiveness is limited. Guidance by intellectual means is more effective in the majority of schoolroom situations. The teacher should employ many devices for guidance and adapt them to different learning situations.

The chief purpose of all guidance techniques and devices is to prevent errors. Errors are best prevented when guidance is given during the initial stages of learning. If guidance is administered during the initial stages, the commission of errors is not likely to result in the development of incorrect habits. However, the learner may profit by committing errors so long as he is conscious of their occurrence and attempts to correct them. Guidance should be continued until it is certain that the learner understands the essential elements of his task. However, too much emphasis upon the prevention of errors may thwart initiative of the learner. Guidance should always reenforce and develop the resourcefulness of the pupil.

CHAPTER XV

MODES OF PRESENTATION

Individuals were formerly classified by some psychologists as visuiles, audiles and motiles, according to whether they learned more efficiently through the sense of vision, audition or muscular sensation. Both subjective and objective methods were used in identifying the several types. The subjective method consisted in having individuals introspectively analyze the method of learning. The objective method consisted in the determination of efficiency in learning by quantitative measurements when stimuli were presented auditorily, visually or tactually. The results obtained from the use of both methods have indicated only that one individual is a better visualizer than another under certain conditions, or that one person is superior to another in an auditory situation. Because the individual's learning efficiency varies with types of materials and with the manner of their presentation under different conditions, it is not helpful to say that any individual is a pronounced auditory, motor or visual type.

A. Efficiency of Various Modes of Presentation

The efficiency of various modes of presentation has been studied with two general purposes. Laboratory studies have aimed to discover how the individual thinks and perceives when a variety of methods are employed. Schoolroom investigations have determined the comparative efficiency of different modes of presenting various school subjects. Both types of investigation have yielded practicable contributions to learning in the schoolroom.

1. Laboratory Investigations.—O'Brien[1] determined the efficiency of 12 modes of presentation in learning meaningful

[1] O'Brien, F. J., A quantitative investigation of the effect of mode of presentation upon the process of learning, *Amer. J. Psychol*, 1921, 32, 249–283.

words and nonsense materials. The objective results of his investigation were supplemented by a detailed analysis of the introspective records of the individuals used in the experiment.

TABLE 34.—AVERAGE EFFICIENCY FOR EACH MODE OF PRESENTATION AS MEASURED BY AVERAGE NUMBER OF PRESENTATIONS REQUIRED FOR LEARNING; ALL OBSERVERS
(After O'Brien, 1921)

Order of presentation	Mode of presentation	Meaningful words	Nonsense syllables	Average two materials
7	Am	5 90	7.83	6 87
3	VA	8.10	5.58	5.84
10	AMm	7.80	5.92	6 86
2	A	6 00	7 33	6 67
11	VMm	9.10	4 17	6.64
8	VAM	7.00	5.83	6 42
5	Vm	4.80	7 58	6 19
6	Am	7.20	5 00	6.10
12	VAMm	4 00	6.90	5 85
1	V	5 90	5 25	5.58
4	VM	3 40	3 42	3 41
9	VAMm	8.00		

V = visual; A = auditory; M = vocimotor; m = manumotor. Last column arranged in order of efficiency with least efficient mode at the top.

The data of Table 34 indicate a wide range of modes of presentation and show that the combined visual-vocimotor method is by far the most efficient in this investigation. However, when the students taking part in the experiment are considered in detail, no one mode of presentation appears to be best for all individuals. Neither is it found that the same method of presentation is best for the same individual when different materials are used. All individuals found it necessary to use vocimotor imagery in learning both nonsense syllables and meaningful words. Manumotor imagery did not play a significant part in either learning or recall, but, when materials were presented in an auditory manner, learning was more efficient when the learner wrote the material than when he did not write it.

The effectiveness of any mode of presentation is relative. The differences between the efficiency of modes of presentation

are influenced to some extent by the differences in experimental procedures which make it difficult to evaluate variable factors and thus compare the worth of one method with another as determined by different investigators. A combination of visual and auditory presentation may be superior to auditory presentation alone for one reason and superior to visual presentation for another. Some factors which condition the efficiency of modes of presentation include[1] the methods by which the function is measured, the stage in the learning process at which accomplishment is determined, the extent to which the individual is familiar with the material and the method of recording responses to tests.

It is usually best to use many avenues of approach in learning. For example, in learning the vocabulary of a foreign language most efficient results are obtained when the learner sees the word, hears it, says it and writes it. In some cases it is desirable to experience the situation by simultaneous stimulation of many sense avenues. This approach is especially advantageous in the case of training deaf subjects who, when they feel speech in their fingers by means of a teletactor and at the same time see it upon the face of a speaker, are enabled to interpret speech more accurately than is possible through the visual impression alone[2] as in the case of lip reading. The principle of utilizing all avenues of approach to learning illustrates the law of association and the development of perceptions. The greater the number of sense organs stimulated, the larger the number of associations formed.

2. Schoolroom Investigations.—Winch[3] conducted extensive studies with children of the primary grades to determine the efficiency of a combined method including visual, auditory

[1] Koch, Helen L., Some factors affecting the relative efficiency of certain modes of presenting material for memorizing, *Amer. J. Psychol.*, 1930, 42, 370–388.

[2] Gault, Robert H., On the effect of simultaneous, tactual-visual stimulation in relation to the interpretation of speech, *J. Abn. & Soc. Psychol.*, 1930, 24, 498–517.

[3] Winch, W. H., Experimental researches in learning to spell, *J. Educ. Psychol.*, 1913, 4, 523–527, 579–592; *idem*, Further experimental researches in learning to spell, *J. Educ. Psychol.*, 1914, 5, 449–460.

and articulatory factors as compared with a silent method of learning to spell. Two equal groups were used, one group learning by the combined method under the supervision of an experimenter or teacher, while the other group learned by the silent method. He found that, when primary pupils were taught by a combined method where the teacher directed the learning of the class, efficiency in spelling was superior to that when the pupils studied by the visual method and were not directed in their learning. Winch, however, believes that with mature and more intelligent pupils the visual method is probably better and suggests that, since the method of life is a visual one, children should be encouraged to learn by it when they become older.

Dumville[1] and Lewis, using the technique employed by Winch, tested the efficiency of learning poems by the silent method as compared with learning them aloud. They found that the silent method produced far better results. The superiority of the silent method may be attributed to several factors including differences in rate of learning, span of apprehension and difficulties in understanding words and phrases. Concerted learning provides little opportunity for these differences to operate, while in silent learning greater flexibility is allowed. With young and backward children there probably is some advantage in learning by the concerted method because of the greater competition involved. Backward children tend to profit to a greater extent by competition than do brighter pupils.

Lacy's[2] results show that for junior-high-school pupils, questions of fact, thinking and moral discrimination can more adequately be reproduced by the method of delayed recall for narrative material which has been presented by a story teller or as reading matter, than when presented through the medium of the motion picture. However, the findings

[1] Dumville, V., and E. O. Lewis, Silent and concerted learning, *J. Educ. Psychol.*, 1913, 4, 356–361.

[2] Lacy, John V., The relative value of motion pictures as an educational agency, *Teach. Coll. Rec.*, 1919, 20, 452–465.

in this field are usually influenced by the age and maturity of pupils. Russell[1] studied material presented in three ways by the regular classroom teacher. In one instance the material was read to the pupils twice in succession. In the second case the subject matter was presented with the advice that pupils read it at their normal rate. In the third instance the group read the material, the impressions being kept constant with those of the first group with regard to time. He found that pupils in grade 5 learn more efficiently by having material read to them than by reading it themselves; that the efficiency of the two methods was about the same in grade 7, while in grade 9 there was a slight superiority in favor of the method of learning by reading.

Auditory methods are generally superior for young children, which is probably due to their limited experience and their difficulty in mastering the mechanical phases of reading. When children are older and have acquired the technique of reading for understanding, the visual methods become increasingly effective.

B. Visual Aids

The term *visual aids* has been used to include several types of presentation, of which the slide and motion picture have been more frequently discussed. The difference between the efficiency of the still and motion picture has not been clearly determined, although the motion picture is more desirable for some phases of instruction. Motion pictures tell the story in action, while still pictures tell the story by suggestion. The motion picture is superior to other visual methods where action is involved. Some advocates of visual aids believe that at least 40 per cent of conceptual learning may be attributed to the sense of vision, while other investigators have been more conservative.

The comparative effectiveness of visual aids as distinguished from lecture and other verbal methods of classroom instruction

[1] Russell, R. D., A comparison of two methods of learning, *J. Educ. Res.*, 1928, **18**, 235–238.

depends upon the nature of instruction and the character of the pupil's[1] previous experience. Other factors include age, intelligence and degree of maturity. Verbal methods of instruction in some instances are superior to visual aids, while in other cases visual methods are more effective. Where teaching involves the utilization of concrete experience, the visual methods of presentation are usually proficient, but in situations where comparison and analysis are required the visual method used alone is relatively ineffective. The pupil's previous experience is an important factor in determining the efficiency of performance. Freeman reports an experiment which shows that one group of pupils which had made a high score after oral instruction had had considerably more experience in the subject matter than a parallel group with which it was compared. On the basis of objective investigation some general principles may be outlined.

1. **The efficiency of modes of presentation varies with the type of subject matter taught.** Some subjects are especially adapted to visual methods. In teaching history, photoplays[2] contribute toward the acquisition and retention of worth-while concepts of cause and effect relationships. In the field of science, demonstration by the teacher is superior to the motion picture because of the greater possibility for explanation of principles involved in the subject. In foreign languages, pictures are effective and suggest the importance of using many avenues of approach. In certain skill subjects which involve the doing or making of something, demonstration is better than the motion picture, although the film is usually superior to many methods with which it is compared. The chief values of motion pictures are found in subjects involving motion or action.[3] In subjects involving skill or understanding of the way a device or a machine operates, motion pictures are usually more efficient than methods with which they are compared.

[1] Freeman, F. N., *Visual Education*, Univ. of Chicago Press, 1924.

[2] Knowlton, D. C., and J. W. Tilton, *Motion Pictures in History Teaching*, Yale Univ. Press, 1929.

[3] Freeman, *op. cit.*

2. Visual aids probably make their greatest contribution when they provide materials otherwise inaccessible to the learner.[1] This is especially true in such subjects as geography and history, when pupils do not have sufficient experience to understand abstract subject matter of textbooks. Visual aids supplement the pupil's limited experience and thus make subject matter more vital. When the pupil is not familiar with objects and experiences treated in courses, two possibilities usually exist: (1) to take the pupil to the object, or (2) to bring the object to the pupil. The latter is usually more practical.

3. Visual aids may be used at the beginning of a lesson where there is unfamiliar subject matter.[2] Visual aids accompanied by verbal discussion are effective in the presentation of abstract subject matter. Visual aids should probably come first when the verbal discussion is more abstract than the visual representation.

4. Visual aids assist in motivating the work of the classroom. Even in cases where experimentation shows that other methods are superior pupils prefer the visual method, especially when motion pictures are employed. This conclusion is confirmed by Knowlton and Tilton, who have summarized the effects[3] of photoplays upon pupil participation as follows:

(*a*) More recitations were made at the request of the teacher;
(*b*) a larger percentage of the class recited;
(*c*) those reciting did so more often;
(*d*) on these occasions more hands were raised;
(*e*) more remarks were volunteered by the pupils, not directly as a result of a teacher's question, *i.e.*, upon those occasions when their own desire to participate more evidently prompted them;
(*f*) a larger percentage of the group so volunteered;
(*g*) those volunteering did so more often;
(*h*) on these occasions more hands were raised for permission to participate;

[1] Weber, J. J., Comparative effectiveness of some visual aids in seventh grade instruction, *Educ. Screen*, 1922.
[2] *Ibid.*
[3] Knowlton and Tilton, *op. cit.*

(*i*) more questions were asked;
(*j*) a larger percentage of the group asked questions;
(*k*) those who asked questions did so more often;
(*l*) fewer contributions came in as a result of outside interest;
(*m*) a larger percentage of the group made such contributions;
(*n*) those contributing did so less often.

5. Visual aids should be considered as supplementary devices in teaching. The indiscriminate use of visual aids may produce an attitude of passivity in the learner. It is only when they are used to supplement other types of presentation that they are justified as teaching devices.

6. Visual aids are more efficiently used in teaching young and immature pupils. The younger the pupil, the greater the need for making concrete and vital the materials of the classroom. As pupils grow older, abstract thinking may be substituted for concrete thinking. Visual aids assist the child in obtaining clearer and more definite ideas of objects[1] and experiences and thus furnish the basis for developing concepts.

C. Sound Motion Pictures

Recent studies have dealt largely with the sound motion picture as a teaching device. Arnspiger[2] compared the effectiveness of teaching with the aid of educational talking pictures in the fields of natural science and music with the usual methods of classroom instruction. The sound pictures were based upon units of instruction prepared in these fields. Nine hundred and fifty fifth-grade pupils in 32 classes and 1,425 seventh-grade pupils in the same number of classes participated in the experiment. The pupils were representative of five cities located in three states. The initial test was repeated as a recall test four weeks after the completion of the last unit of instruction.

Arnspiger's results show that these talking pictures make distinct contributions to learning and recall. The gains in

[1] Wood, B. D., and F. N. Freeman, *Motion Pictures in the Classroom*, New York, Houghton Mifflin, 1929.

[2] Arnspiger, V. C., The relative effectiveness of sound motion pictures in teaching elementary science and music, *Educ.*, 1933, **53**, 332–335.

learning made by pupils using the talking motion pictures were superior in every case, the percentages of superiority ranging from 22 to 30 in natural science and from 18 to 34 in music. The average gains for the recall test were also greater for the experimental than for the control group, the percentages of superiority ranging from 9 to 32.

Clark[1] determined the value of educational sound motion pictures as compared with silent motion pictures and lecture demonstration. Sound films in which the sound was a vital and realistic part of the film were compared with lecture demonstration and silent motion pictures. An indirect comparison with the lecture presentation as the common element reveals the greater effectiveness of this type of sound film over the silent film. His results indicate that sound films of the type in which the sounds are an integral part of the picture are superior to the demonstration and silent films in maintaining and stimulating interest. The silent films accompanied by captions were superior to the sound films of the lecture type. The spoken voice detracted from the value of the film in conveying specific information. Rulon[2] found that the group receiving instruction by means of a sound film in addition to the textbook showed a superiority over the group taught by the textbook method alone of 20 per cent for an immediate test and 38 per cent for a test three months later.

The experiments on the teaching effectiveness of sound motion pictures have dealt primarily with science. This field lends itself most readily to visual aids, but results should be applicable to other subjects. With the lecture type of sound motion picture there is no opportunity for variation of method of presentation to provide for individual differences in interests and abilities. Motion pictures when accompanied by verbal directions, and adequate explanation of the essential features seen, are more effective than the silent film. The sound motion

[1] CLARK, C. C., Effectiveness of sound films as aids in classroom teaching, *Educ.*, 1933, 53, 337–342.

[2] RULON, P. J., *The Sound Motion Picture in Science Teaching*, Harvard Studies in Educ., Harvard Univ. Press, 1933.

picture is in general more effective than silent films because it utilizes more avenues of presentation and stimulates greater interest.

D. Graphic, Tabular and Textual Modes of Presentation

Washburne[1] conducted an experiment to test the efficiency of graphic, tabular and textual modes of presentation. A brief account of the economic history of Florence was used as learning material. The account contained a paragraph which dealt with specific quantitative facts; for each form of presentation the paragraph was varied, the material for the paragraph remaining constant. In some of the forms the paragraph was given as a statistical table, in others as a bar graph, pictograph or line graph, and in still others the data were presented in narrative form. Several thousand junior-high-school pupils were used for the experiment and identical tests were constructed for all forms of presentation. These involved two parts. One part dealt with the narrative in general and the other with the data of the quantitative paragraph.

Washburne analyzed his findings in order to answer certain specific questions. Should the number of items to be presented determine the arrangement of items? Should one form of presentation be used when there are comparatively few items to be presented and some other form when there is a larger number of items? Which method of presentation is most conducive to recall of quantitative data—the amount of data or the arrangement? Is the effectiveness of presentation conditioned by visual differences or by logical arrangement of materials? Would the presentation of numbers which are grouped in a certain way be affected by the addition of bar diagrams, pictures or lines? The purpose foremost in mind was to establish some general principles which might govern the use of various forms of graphic, tabular and textual modes of pres-

[1] Washburne, John Noble, An experimental study of various graphic, tabular and textual methods of presenting quantitative material, *J. Educ. Psychol.*, 1927, **18**, 361–376, 465–476.

entation. The general rules developed are presented in two parts as follows:

1. For complex or slightly complex static comparisons use a bar graph.
2. For extremely simple static comparisons use a pictograph.
3. For dynamic comparisons use a line graph.
4. For specific amounts use a statistical table.
5. For specific amounts use round numbers in numerical form (5000).
6. For specific amounts use as few facts as possible.
7. Never present numerical data in textual (paragraph) form *if* there are more than one or two items to be presented.
8. When numerical data are presented textually, use written numbers (five thousand dollars) for static and dynamic comparisons; and numerals (5000) for specific amounts.
9. Use questions after a graph to emphasize its chief features.

The following rules deal with the recall value of the several methods of presentation:

1. Both logical and visual factors, in the grouping of quantitative material, have a distinct effect upon the recall of the material. Logical factors affect most the recall of relative amounts (static comparisons) and visual factors affect most the recall of specific amounts.
2. The simpler the visual pattern and the fewer the data, the more specific the recall.
3. Round numbers (numerals) are more favorable to the recall of specific amounts than are detailed numerals and written numbers.
4. Increase in the number of data presented in a graph affects unfavorably the recall of specific amounts.
5. The paragraph is, in general, the form which is least favorable to recall of quantitative data whether general or specific.
6. The bar graph is the most favorable to the recall of relative amounts (static comparisons) when the comparisons called for involve a fair degree of difficulty.
7. The line graph is the form most favorable to the recall of relative increase, decrease, and fluctuation (dynamic comparisons).
8. The statistical table is the form most favorable to the recall of specific amounts.
9. Questions following a form increase the effectiveness of the form especially in regard to the recall of those data which the questions concern.
10. The addition of further reading material and quantitative data does not alter the relative effectiveness of the forms.
11. The relative effectiveness of the forms was the same in grades 7, 8 and 9.

12. There is no correlation between the recall of specific amounts and of static and dynamic comparisons.

13. There is no correlation between the recall of numerical and non-numerical facts.

E. Summary

Individuals react according to materials and the manner of their presentation under varying conditions. It is doubtful if any individual is a pronounced auditory, motor or visual type. The teacher should use several modes of presentation and obtain for classroom use many teaching devices. The auditory method of presentation is probably better for young children. However, as age increases, perception becomes more complex and by the time the child reaches adolescence visual methods become increasingly more effective.

The function of visual aids is to furnish the teacher with materials which will supplement and enrich the various mediums of instruction usually employed. Visual aids do not supplant the common mediums of instruction nor least of all the teacher. The relative efficiency of visual aids as compared with lecture and other verbal methods of classroom instruction depends upon the nature of the instruction and the pupil's previous experience. Visual aids assist in developing clear and definite ideas of objects and experiences, and thus furnish concrete materials necessary for stimulation of thought and the development of concepts. The sound motion picture is more effective than the silent motion picture because it employs more avenues of approach and thus develops a larger number of associations.

Various graphic, tabular and textual methods may be used with efficiency in the presentation of quantitative data. In the presentation of specific amounts, statistical tables are effective; in making dynamic comparisons a line graph should be employed, and for static comparisons the pictograph may be used.

CHAPTER XVI

TECHNIQUES OF STUDY

Study may consist in the effort to acquire skill, to memorize by rote, to comprehend materials or to solve problems. If one conceives education to be a process of accumulating knowledge, study consists in the effort of memorizing and comprehending materials. In such a case one becomes primarily a consumer of knowledge and studies for the purpose of reproduction for quizzes and examinations. If the aim is to develop ability to solve problems, the student organizes and evaluates material according to definite purposes. Irrespective of the conception one has of education, study implies the concentration of attention for the purpose of making an intelligent response. No matter how efficiently subject matter is presented by textbook or lecture, the entire process is ineffective unless there is an intelligent response to the material.

There has been little research relating to the procedure used to assimilate material from an assignment, although this is the problem about which we are most concerned. Rules for study which have been emphasized by writers in this field have little scientific foundation. These rules have dealt chiefly with external conditions, good health and appropriate amounts of sleep and relaxation, rather than with the procedure used to assimilate and comprehend learning materials.

Investigations indicate that there are wide variations in study habits. Through a trial-and-error process students strive to attain results desired by their teachers who, themselves, may have little conception of study. Some teachers attempt to aid their students by pointing out significant elements in the assignment while others advise that material be read and reread in a mechanical fashion. In any case instruction in how to study has been an incidental and haphazard process.

A. Variations in Study Habits

Dynes,[1] by means of a study habit check list, determined the methods used by high-school students in studying a topic in social science. The pupils were required to study individually a definitely assigned topic and the investigator checked the

Table 35.—Summary of the Data Collected by the Use of the "Study Habit Check List"
(After Dynes, 1932)

Methods of study	School G (92 pupils)				School H (52 pupils)			
	Number		Percentage		Number		Percentage	
	Yes	No	Yes	No	Yes	No	Yes	No
1. Pupils went to work at once	92	..	100	..	52	..	100	
2. Rapid survey of work	10	82	11	89	..	52	..	100
3. Rapid survey of reading	..	92	...	100	..	52	..	100
4. Intensive first reading								
5. Times pupils read material								
6. Reread isolated parts	14	78	15	85	..	52	...	100
7. Underline words, phrases	6	86	7	93	..	52	...	100
8. List words, dates, events	7	85	8	92	1	51	2	98
9. Take notes on material	7	85	8	92	4	48	8	92
10. Outline material	8	84	9	91	3	49	6	94
11. Written abstract or summary	..	92	...	100	..	52	...	100
12. Use self devised questions	..	92	...	100	..	52	...	100
13. Study notes taken (85 took no notes)	5	2	71	29	3	1	75	25
14. Use dictionary, maps, etc.	..	92	...	100	9	43	17	82
15. Use "whole method" of study	84	8	91	9	46	6	88	12
16. Use "part method" of study	8	84	9	91	6	46	12	88
17. Use method of recall	9	83	10	90	5	47	10	90
18. Concentrate on work	92	..	100	...	52	..	100	
19. Systematic in study habits	90	2	98	2	52	..	100	
20. Annoyed by work	..	92	...	100	..	52	..	100
21. Read and reread, regular method used	68	24	74	26	29	23	56	44
22. Ordinarily took notes when studying	24	68	26	74	23	29	44	56
23. Method used: read only	85	7	92	8	48	4	92	8
24. Method used: read and took notes	7	85	8	92	4	48	8	92

School G: Range (6 to 15), 9 min. Average, 11.08 min. School H: range (6 to 22) 16 min. Average, 12.1 min.

School G: 14 pupils read the material only once; 78 read the whole or part of the material the second time. School H: 25 pupils read the material only once; 27 read the whole or part of the material the second time.

[1] Dynes, J. S., Comparison of two types of study, *J. Exper. Educ.*, 1932, 1, 42–45.

procedures used. Dynes's study is significant because, rather than depending upon pupils' own opinions of their study habits, he checked their techniques as they occurred in studying the specific assignment. The techniques employed by these pupils are found in Table 35, which shows a wide range of procedures. It was found that when pupils are left to their own initiative they will use the procedure which appeals to them individually. Most of them prefer to read and reread material until they are able to reproduce it.

Variations in study habits are also found among students in colleges and universities. Parr,[1] by means of a questionnaire, studied the procedure used by 60 undergraduate students in studying an assignment in educational psychology at the State University of Iowa. One part of the questionnaire dealt with the study habits of these students and the other consisted of a brief test which covered the material of the assignment. Replies to the questionnaire were classified according to those who read the assignment once, those who read it twice and those who used neither of these procedures. He found that there were 10 variations made by 35 students in reading the chapter once and that the most frequent variation was to read the chapter once and then ask questions about it. There were also 11 variations made by 15 students who read the chapter twice. He found that there were 24 variations made by these 60 students and that few of them use any plans recommended by experts in this field. On the basis of the test results it was shown that the typical student could recall only a few salient points discussed in the textbook assignment.

These variations in study habits forcefully suggest the need for special training. It would appear that there is little improvement in methods of study as pupils pass through the various levels of education. Wilson[2] tested 837 pupils between grades 7 and 12 on their knowledge of how to study and found

[1] Parr, Frank W., How college students prepare an assignment, *School & Soc.*, 1930, 31, 712–713.

[2] Wilson, C. B., Pupils' knowledge of study techniques, *Educ.*, 1932, 52, 362.

that the median number of questions correctly answered by grade 12 was 13.8, and by grade 7, 11.8. These findings show that pupils' knowledge of techniques of study improve but little with maturity. However, even when the pupil is familiar with good techniques of study there is no assurance that he will put these into practice when he is left to his own initiative. A program of study should include both a knowledge of study technique and the application of this knowledge in studying assignments.

B. The Effectiveness of Special Training

Newlun[1] studied the effect of spending 10 minutes a day for several weeks in teaching summarization in fifth-grade history. The exercises devised to develop ability in summarizing consisted among other things in teaching pupils to assign a title for the subject studied, to select and arrange important facts, to prepare oral and written summaries and to evaluate those written by themselves and other pupils. This training not only improved the ability to summarize historical material, but produced improvement in learning history. Newlun believes that the most important outcome developed by training in summarizing is the ability to distinguish between important and irrelevant facts.

Barton[2] approached the study problem in the junior and senior high school from the standpoint of training in outlining which included searching for the main points in the paragraph, making outlines, finding facts to support an opinion, filling in an outline and discovering major topics in the material. This training enabled pupils to learn more facts. Barton believes that outlining is one of the most effective aids in studying content subjects.

Dynes[3] compared the effectiveness of two methods of study-

[1] Newlun, C. O., Teaching children to summarize in fifth-grade history, *Teach. Coll. Contrib. Educ.*, 1930, No. 404.

[2] Barton, W. A., Outlining as a study procedure, *Teach. Coll. Contrib. Educ.*, 1930, No. 411.

[3] Dynes, *op. cit.*

ing history in the high school. In method X pupils read and reread the material, while in method Y the pupils (1) gave the material a rapid reading, (2) reread the material, underlining essential parts and taking notes, (3) reviewed, underlining portions and notes, (4) wrote summary of material and (5) recalled as much as possible of that which had been read. Method Y proved to be slightly superior to method X both for immediate learning and retention. The superiority of method Y is probably due to the opportunity for developing many meanings and associations in the material. This experiment although not conclusive indicates that pupils may improve their knowledge of a subject by using many aids in studying an assignment. Reading and rereading as in method X is a mechanical process which affords little opportunity for the development of meanings.

The first week of school should be devoted to discovering the study habits of pupils and to special exercises which provide for improvement. This training may consist in the assignment of a topic, directing attention to its important points and problems and requiring pupils to report upon their methods of studying them. Such reports when analyzed will illustrate wide variations in study habits and direct attention to uneconomical procedures. Teachers will discover from such a plan marked improvement in the ability of pupils to learn the main ideas of an assignment.

Finch[1] developed a series of study tests which was given to make high-school students aware of the need for better study habits and to create a desire for improvement. The first test was designed to determine whether students would select important information in response to questions. A second test attempted to determine whether students knew the meaning of certain terms used by them in their answers to questions in the first test. A third test measured the students' knowledge of using textbooks, while a fourth was designed to measure the following abilities:

[1] Finch, Charles E., Junior-high-school study tests, *School Rev.*, 1920, 28, 220–226.

1. Ability to select important things told in a paragraph.
2. Ability to write intelligent questions about a paragraph.
3. Ability to collect information suggested by a simple outline.

Finch found sufficient evidence to show that pupils who answered the questions could find the subject or leading thought in the lesson and could supplement textbook materials with thoughtful questions about the important topics.

In colleges and universities the problem of how to study is beginning to be an important feature of freshman week. Jones[1] describes a "how to study" course used with freshmen of low scholastic standing in the University of Buffalo. Twelve lectures one hour in length were delivered, eight on the technique of study by those teaching specific courses, and four by other speakers on more general topics. Students were required to take notes which were collected at the end of each lecture and carefully graded. The next day each student was interviewed and his notes were discussed according to their strong and weak points. An objective scoring device was used which showed that marked improvement had taken place during the three weeks of training. Many of the students had never taken notes and knew little of their value. A valuable outcome of the program was drill in writing English themes under pressure of time in the presence of an instructor. These themes were read aloud and criticized with special attention to sentence structure and clarity. Lectures on content, purpose, memory, habits and attentiveness were especially appreciated by these students. The program also included training in the assimilation of book content, use of the library, methods of memorizing foreign words and taking notes from difficult material. The plan was sufficiently successful to justify its continuance as a regular feature of freshman week at the university.

Wrenn[2] has recently developed a study habits inventory with students of Stanford University. The inventory is based upon the assumption that where two students are equal in

[1] Jones, E. S., The Buffalo course for college freshmen: how to study, *School Rev.*, 1929, **37**, 564–565.

[2] Wrenn, C. Gilbert, *Study habits inventory*, Stanford Univ. Press, 1933.

intelligence and unequal in scholarship their habits of study are likely to differ markedly. The inventory is thus validated on the basis of the extent to which students of high and low scholarship differ in their answers to a series of questions regarding study practices. It was found that in 30 of 69 study habits students of high scholarship differed markedly from those of low scholarship. Each item of the inventory is supposed to have significant diagnostic value in revealing study habits which influence high or low scholarship.

The nature of the inventory may be made clearer by listing sample questions under each of its three parts:

	Rarely or never	Sometimes	Often or always
A. Note-taking and reading techniques.			
1. I miss important points in the lecture while copying down notes on something which has gone before.	______	______	______
2. I have trouble picking out the important points in material read or studied: take down material which later on turns out to be merely explanatory or irrelevant.	______	______	______
B. Habits of concentration and school interests.			
1. I find it hard to keep my mind on what I am studying—don't know what I have been reading about when I get through.	______	______	______
2. I have a tendency to "day-dream" when trying to study.	______	______	______
C. General habits of work.			
1. My study periods are often too short for me to get "warmed up" and concentrate.	______	______	______
2. I am careful to make proper use of reviews—reviewing notes taken, setting aside time for daily or weekly reviews during quarter, concentrating review mainly on the points where I feel weakest.	______	______	______

The students' general rating on the inventory may be determined by algebraically adding the weights assigned for each answer. However, Wrenn recommends that each question be individually evaluated. Those questions having high negative weights represent habits that are in need of remedying, while those having high positive rating indicate desirable study practice. The inventory may be used as a basis for identifying good and poor study habits and for stimulating self-analysis and desire for improvement on the part of the student.

C. Some General Types of Study

Types of study include in the case of motor learning the acquisition of skill, and in mental learning the acquisition of ideas, which embraces rote memorization, apprehension of materials and problem solving.

1. **Acquisition of Skill.**—In the acquisition of skill there is an attempt to get a clear conception of the act to be performed either by explanation or by demonstration. The learner also makes an effort to analyze the various skills which compose the act and practices upon them in order that they may become habitual. Finally, when the various skills have become automatized through practice, there is an attempt to organize them into the larger whole which represents the complete act.

2. **Acquisition of Ideas.** *a. Rote Memorization.*—Rote memorization consists in reading and rereading material until it may be reproduced with exactness. It is not necessary that the material be meaningful or that associations be established other than those inherent in the material itself. Pupils frequently commit to memory without comprehending the material memorized. Because rote memorization may take place without comprehension, this technique of study when used alone has limited value. The pupil should first make sure that he understands the material to be memorized. Rote memorization should be used only as a means of fixating materials which have already been comprehended.

b. Comprehension of Materials.—This technique consists in the process of "getting the story" and in developing meanings and associations.

"Getting the story" is that technique which may be considered as having an intermediary position between rote memorization and the development of meanings and associations. The process of "getting the story" does not require exact reproduction of words, but rather the reproduction of connected events in their proper sequence. The story may be told by the teacher or read and repeated orally by the pupil in his own words with such promptings as may be necessary to secure the proper sequence of events. This method is greatly enhanced for young children by dramatizing the story. The enactment of events tends to build up within the mind of the child mental pictures of events which follow in rapid succession. It is during the early life of the child that he is likely to be accused of story telling because of his tendency to repeat to others the action pictures developed within his mind, which often seem as real as if the child had actually taken part in the activity. This technique is aided by associations formed with personal action and the projection of the pupil's personality into that of some character in the story.

The process of deriving meanings and developing associations is the most common technique used in the schools. It requires the translation of words and ideas of others into the pupil's own words and thoughts and necessitates knowledge of word meanings and combinations. It consists in attempting by means of various associations to understand the viewpoint of the author and to think thoughts which are in harmony with those expressed by the author. This technique is required primarily in class recitation and is measured by both objective and essay examinations. The technique is also used when the purpose is to consume knowledge as in the reproduction of textbook material.

c. Problem Solving.—In the problem-solving technique of study each assignment is considered as a problem requiring solution. Past experience and facts from many sources are

brought to bear in an effort to solve the problem. The pupil does not necessarily think with the author, but rather thinks in response to the situation presented. He uses not only materials of the lecture, textbook and class discussion but all pertinent data, and makes generalizations which are then tested for validity of the reasoning process. This technique requires the greatest amount of guidance and is least often used.

The choice of the type of study is influenced by the kind of subject matter, the type of response desired by teachers and individual differences among pupils. In studying such subjects as drawing and writing, music, typewriting, physical education and some subjects which require laboratory exercises, the motor type of study is appropriate. For spelling, mathematical combinations, locations, formula and the mechanical acquisition of learning material which requires exact reproduction, rote memorization is necessary. For reproduction of narrative literature, prose, poetry and drama, incidents of biography, history, adventure and all learning material where action and events follow in narrative sequence, the story technique of study is effective. In subjects where the purpose is to comprehend that which is read and to translate words and ideas into one's own thoughts as required in most subjects, the technique of acquiring meanings and developing associations is important. When the purpose is to determine cause and effect, to trace the processes of development, to formulate new principles or to develop new knowledge through the reorganization of experience, the problem-solving technique is appropriate.

Pupils adapt their methods of studying to the objectives of their teachers. Some teachers emphasize the acquisition of a large body of facts and measure achievement in terms of recall. Others stress the solving of problems and measure achievement in terms of recognition examinations and the ability to make applications in practical situations. When the response required is exact reproduction, rote memorization is chosen. When the problem-solving method is emphasized, the pupil will adapt his technique of study to this objective. Objective examinations primarily require rote memorization

and comprehension of meanings because factual information may more easily be scored. Essay examinations may emphasize rote memorization or they may require comprehension and problem-solving ability.

Pupils who have special ability in memorizing soon attempt to develop this type of study and may excel in the mechanical processes of learning. Others who have little aptitude for memorizing develop the problem-solving type of study. Instead of memorizing lectures and textbooks, such pupils raise questions as to why, what and how; they attempt to test the validity of statements on the basis of experience and general information rather than to accept them on the authority of the author. If pupils find it difficult to apprehend materials and solve problems, they are likely to emphasize rote memorization. Although bright pupils may find it easy to study by rote memorization, comprehension of materials and problem-solving types are more satisfying.

D. Some General Aids to Study

Although techniques of study may vary in their effectiveness with different types of subject matter, teaching objectives and individual differences among pupils, there are some aids which apply in general to all learning situations.

1. **Making a Study Program.**—There should be a program with definite hours for studying certain subjects and a place favorable for efficiency. A definite time and place for study result in economical habits. It is sometimes observed that pupils who carry heavy schedules and outside work study with more efficiency than others who carry smaller loads and assume fewer responsibilities. These students find it necessary to budget their time and consequently arrange for specific tasks at various periods of the day and week. The practice of budgeting time produces an attitude of concentration and interest.

2. **Problem-solving Attitude.**—Study of an assignment should be begun with the attitude that there is a problem to be solved. This attitude implies a search for pertinent facts, an

examination of various parts of the assignment according to relationships and an effort to reconcile points of view. The pupil assumes a tentative attitude toward problems which arise until he has evaluated them for their significance. It is advantageous for the individual to determine how he would himself develop the topic under consideration. By relying upon his own experience and by thinking constructively about the topic, the pupil may make a list of the items which he would include. When this plan is used he often finds that he will develop many of the topics discussed in the textbook or collateral reading. This procedure provides a basis for stimulating constructive thinking about the assignment and develops resourcefulness.

3. **Relating Old and New Assignments.**—By relating the present material to those assignments already completed, the pupil is led to see relationships and sequences and has a basis for beginning the new work. Courses are developed according to sequences and relationships. Each assignment is generally related to every other assignment in the course so that it is desirable to review previous material before studying the advanced work. Relating old and new assignments not only furnishes a background for the new work, but is one of the most effective means of stimulating interest.

4. **Outlining.**—Outlining material according to major and contributing elements is an effective method of study. Outlining furnishes a basis for logical arrangement and thus enables the pupil to distinguish between important and irrelevant material. In courses which require a large amount of textbook and collateral reading the outline is the only recourse for organizing and evaluating information. For this reason every course should provide training in making synopses and abstracts. Such outlines aid in evaluating a large body of isolated and disorganized facts. Outlining not only aids in immediate learning but develops many useful associations which assist in remote reproduction.

5. **Making Applications.**—Acquired knowledge should be applied as soon as possible. The application of knowledge

affords a basis for the development of meanings and interpretations which make the material studied a part of the pupil's thinking. It is doubtful whether anything is efficiently learned until one is able to apply it in a practical situation. Formulas and rules in mathematics have meaning when they are applied to practical mathematical problems; theories and hypotheses in social sciences have significance when there is an attempt to reconcile them in terms of observation and experience. Application furnishes a means for checking misconceptions and developing new interpretations.

6. **Taking Notes.**—One of the most universal aids to study among high-school and college students is taking notes during the recitation. Notes should be confined to the important points developed by lectures and class discussions and should furnish a basis for organization. Taking notes aids in the organization of materials and furnishes a tangible basis for review. However, if note taking is overemphasized it may defeat its purpose. The pupil may be so busily engaged in taking notes that he gives little attention to the development of ideas involved in the notes taken. Consequently notes should be confined to major topics. After the recitation notes may be rewritten in greater detail and logically arranged for future reference.

7. **Frequent Recall.**—Although the recitation furnishes a basis for recall and an opportunity to make learning materials a part of one's thinking, it is not sufficient in itself. There should be an attempt frequently to recall the ideas acquired during the progress of the course. Recall enables one to keep materials fresh in mind and forms a basis for checking the accuracy of learning.

8. **Overlearning.**—Although overlearning in its technical sense implies repeating or practicing material beyond the point of immediate reproduction, it has other implications. It may include assimilating and evaluating subject matter with little visible practice. It may be a process of silently thinking about the facts or theories read with a view to reconciling and logically arranging them for future reference. The processes of assimila-

tion and evaluation may be enhanced by group discussion, by making applications or by further reading. Overlearning of this nature is of the greatest importance for both immediate and remote reproduction.

9. Determining Meanings of Terms and Concepts.—Comprehension and problem-solving techniques of study require adequate understanding of terms and concepts. Such understanding is fundamental to progress in any subject and especially in scientific and technical fields having peculiar terminology. It is essential that each new term or concept be understood as it occurs in reading or class discussion. Dictionaries, special glossaries and lists of significant terms and concepts should frequently be consulted.

10. Learning by Wholes.—It is generally better to study material as a whole than to study it in small parts. The whole method furnishes greater opportunity for developing meanings and relationships in such a way that each part complements every other. In the case of long or difficult material it may be more economical to give especial attention to various parts which should be so organized that they are related to the larger whole. Studying by wholes not only aids in organizing materials for learning but offers greater advantage for retention.

E. Specific Aids for Special Subjects

Each subject affords a slightly different study approach from every other subject. Comprehensive treatment of the study problem would include principles and aids for study in each subject of the school. A few aids for typical subjects are outlined:

History.[1]

1. Before beginning the reading of the lesson in history be certain that you understand the assignment. It should give you a definite purpose for your reading, that is, you should understand what information you are to find and what use you are to make of it.

[1] Monroe, W. S., and D. K. Mohlman, Training in the technique of study, *Univ. Ill. Bull.*, 1924, 20.

2. First, read over the entire assignment rapidly in order to get the general trend of thought and the main ideas. Give attention to the paragraph headings and the marginal summaries.
3. Next read over your lesson a paragraph at the time. Read it carefully. Look up the meanings of unfamiliar words. Locate places mentioned on the map. Read paragraphs and sections to which cross references are made.
4. Underline the important sentences. However, you should be certain that the sentence is important before you underline it.
5. As you study keep the aim of your assignment constantly before you.
6. Try to determine the reason for the statements which the author makes.
7. Study each paragraph until you are able to give the main points without looking at your book. Commit to memory important names, dates and definitions.
8. When you have finished an assignment, review it in your mind and summarize it by recalling the most important points. If your lesson consists of several divisions, do this for each division.
9. Spend at least as much time thinking about your lesson as in reading about it.
10. Formulate questions which in answering will require an understanding of the most important ideas in your lesson.
11. Try to answer the following questions:
    a. What is the relation of today's lesson to the general topic you are studying and what does it contribute to this topic?
    b. What is the relation of the general topic to the school subject?
12. When you have finished studying a chapter prepare an outline of it. If you do not understand how to begin such a task ask your teacher to help you.

English Literature (Prose).[1]

1. Think over the title of your assignment and decide what it will be about.
2. First read the entire lesson through and get the general trend and the main ideas.
3. Next read it through more carefully, trying to understand everything the author says.
4. Look up and read the notes given in your book.
5. In case you do not derive a satisfactory meaning from the context look up the meaning of the words which you do not know.
6. Look up information in regard to places and historical names if such occur in your lesson.

[1] Monroe and Mohlman, *op. cit.*

7. Pick out the important ideas in your assignment. Indicating them by an underline is a good way, but you should make certain that the words selected express the important idea before you underline them.
8. Write out in a sentence or two the central thought of your lesson.
9. Decide whether you agree with the statements which the author makes.
10. At the end of your study summarize the lesson. Be sure to include in the summary all of the important points.

Geometry (Originals).[1]

1. Identification of the given and required as stated in the theorem.
2. Making oneself certain of the exact meaning of each significant word used in the theorem.
3. Selecting from the theorem those words and phrases which represent separate drawing operations and placing these in the order in which they have to be drawn.
4. Drawing the figure.
5. Recalling in terms of the figure what is to be proved.
6. Recalling to mind all facts developed in the past which might have any bearing on the desired proof.
7. Noting all the facts about the figure which are known to be true either because of the "given" or because of what follows directly from the "given."
8. Bringing the facts of element (6) to the figure, (mentally) applying them to the unknown arising from element (5), determining their potency as leading to the facts of element (7) and discarding them or using them as they seem to give dissatisfaction or satisfaction.
9. The syllogistic organization of the facts finally selected in element (8).

F. Summary

Study is the concentration of attention upon a specific task for the purpose of making an intelligent response. It may be directed toward the acquisition of skill, rote memorization, comprehension of materials or the solution of problems.

The wide variation in habits of study is an indication of many uneconomical methods. Uneconomical habits may manifest themselves by a lack of clear objectives, poor organizing ability or ill-adapted techniques. Training in how to study

[1] Butterweck, J. S., The problem of teaching high-school students how to study, *Teach. Coll. Contrib. Educ.*, 1926, No. 237.

produces improvement both in study methods and in learning. The first week of school should be devoted to discovering methods of study and to making suggestions for improvement. Training in how to study is becoming an important feature of freshman week in college and university.

General types of study include the acquisition of skill and the acquisition of ideas. In acquiring skill there should be a clear conception of the act, the division of the act into its various skills and drill upon these skills until proficiency is attained. Finally, these specific skills should be organized into a complete unit. In acquiring ideas there is rote memorization of material which may not be meaningful; comprehension where there is translation of words and thoughts of the author into one's own words and ideas; and problem solving where one responds to the total situation and does not necessarily think in terms of the author's point of view. The use of these general types is influenced by the kind of subject matter, the objectives stressed by teachers and individual differences among pupils.

General aids to study include: (1) making a study program, (2) a problem-solving attitude, (3) relating old and new assignments, (4) outlining, (5) making applications, (6) taking notes, (7) frequent recall, (8) overlearning, (9) determining meanings of terms and concepts and (10) learning by wholes. Each subject is sufficiently distinct to justify its own aids and principles of study.

CHAPTER XVII

THE MEASUREMENT OF ACHIEVEMENT

Improvement in school implies desirable changes produced in pupils as a result of having taken various subjects; to determine such changes dependable instruments of measurement are necessary. There are three types of formal measuring instruments for the determination of achievement. These types include the essay or traditional examination, the standardized educational test and the objective classroom examination.

Although the essay examination always has furnished and probably always will furnish a basis for measuring achievement, the subjectivity of its scoring has caused its usefulness to be questioned. It is well known that the marks which teachers assign to the work of their students are unreliable. Dearborn,[1] in an investigation at the University of Wisconsin, pointed out wide differences in the standards of marking employed by different teachers. Starch and Elliott,[2] in an investigation at the same institution, found that when a paper in geometry was graded by 116 competent judges the marks assigned varied from 28 to 94 per cent with 70 considered as passing. In another study Starch pointed out gross inequality of marking in English, mathematics and history.

Marks vary, not only with different teachers on the same paper, but with the same teacher under different conditions. Such conditions have led to an effort to standardize the process and make the marking of the written examination more objective. The entire field of examinations has, therefore, undergone revision so that at the present time objective

[1] Dearborn, W. F., School and university grades, *Univ. Wis. Bull. High School Studies*, 1910.

[2] Starch, D., and E. C. Elliott, Reliability of grading high-school work in mathematics, *School Rev.*, 1913, 21, 254–259.

examinations are widely used. Interest in measurement is centered chiefly in the standardized educational test and the objective classroom examination.

A. Standardized Educational Tests

One of the most significant movements in education during the past quarter of a century has been the development of standardized educational tests. This movement has now reached a stage in its development where such tests have been constructed for all of the major subjects of the elementary school, secondary school and college. The number of tests has become so large that the difficulty is not in obtaining a test for use, but in selecting one which will prove most appropriate for the purpose. The standardized educational test is constructed on the basis of analysis of textbooks and courses of study from various sections of the country and its materials are supposedly representative of what the schools teach. In the determination of the content of such tests use is also made of pooled judgments from typical teachers and examinations given over a period of years. Items from such sources are submitted to representative pupils and their reactions studied. The inclusion of content is thus determined on the basis of pupil reaction rather than upon expert opinion. The standardized examination furnishes a sound basis for measuring achievement for diagnosis, classification and promotion.

Standardized educational tests emphasize the measurement of various aspects of subject matter, and diagnose pupil ability according to these several divisions or topics. However, it is not certain what abilities, skills or understandings are measured by such content. The assumption is that certain types of objective questions measure various abilities.

Items of the standardized test may be classified as recall or recognition. Recall questions are usually devised with cues to assist recall. In recognition questions, answers are provided and the pupil is required to select the correct response. It is generally assumed that recall questions tend to emphasize the acquisition of information while recognition questions measure

problem-solving ability and reasoning. The standardized educational test probably measures in some degree these two abilities, although power of organization, English expression and ability to apply knowledge are not measured, not to mention many habits, skills and attitudes which are desirable outcomes of teaching. These limitations should be recognized and test scores should be supplemented by other measures of efficiency.

1. **Criteria for Evaluating Tests.**[1]—Tests may be evaluated on the basis of validity, reliability, objectivity, discrimination and norms.

a. Validity.—Validity indicates the extent to which a test measures that which it is designed to measure. A test in arithmetic is valid if it measures arithmetic and not handwriting, English grammar or punctuation. It is doubtful whether the teacher using essay examinations ever grades entirely upon knowledge of the subject, but rather upon many abilities, including spelling, punctuation, marginal spacing, grammar and organization, which make validity difficult to determine.

Validity in its technical sense implies both validity of source and function. Validity of source means that a test includes items with which pupils have had an opportunity to become familiar. Since standardized educational tests use materials from representative textbooks, courses of study, pooled judgments and examinations, they presumably are valid according to source. However, since each school is somewhat different from every other in its emphasis upon certain materials and methods of presentation, it is doubtful whether any standardized test is entirely valid according to source for a specific use. These tests cover salient material and are thus valid for general purposes.

Validity of function is statistically determined by two general methods. One method is to give the test to a large representative group and determine the extent to which pupils who are found in the various quarters on the total test answer correctly

[1] For a discussion of criteria for evaluating tests, see W. A. McCall, *How to Experiment in Education*, New York, Macmillan, 1923, Chap. 5.

its individual items. In general, pupils who are found in the highest quarter on the total test should pass item 1 with a larger percentage of success than do those in the lowest quarter. Likewise there should be some differentiation in this respect among all of the pupils found in the various quarters. When this criterion is used, any question originally selected which shows insufficient discrimination to justify its inclusion is discarded.

This procedure may also be used on the basis of percentages of success of questions irrespective of the standing of pupils on the total test. Items which permit of 100 per cent success as well as those of no success are usually eliminated. The criterion for the inclusion or elimination of items varies with different authors, although it is generally agreed that no item shall be incorporated which is either too easy or too difficult. The aim is so to construct a test that no one fails to achieve some success while no one makes a perfect score. When the test has been subjected to this criterion and invalid items eliminated, validity of function is automatically increased. This method is termed *inside criteria* because the various items of the test itself are used in establishing validity.

An author may also correlate success on the various parts or divisions of the same test when it is desired to determine whether the different parts measure the same or different abilities. In so far as the different parts of the same test correlate insignificantly with each other, it may be assumed that they measure different abilities.

A second method for determining validity may be termed *outside criteria.*[1] After a test is constructed it may be correlated with various outside criteria such as teachers' estimates, marks in the subject and other tests of known or assumed validity designed to measure the same abilities. The assumption is that, if the test correlates significantly with other measurements of the same abilities, it is valid. However, it is

[1] For a discussion of the statistical method of determining validity according to outside criteria, see H. E. Garrett, *Statistics in Psychology and Education*, New York, Longmans, Green, 1926, Chap. 6.

not certain what a test measures according to this criterion, because it is questionable whether the criteria used for the establishment of validity are in themselves valid. Correlating tests with outside criteria furnishes a basis for determining that which the test tends to measure. Most manuals of instructions which accompany tests furnish data relative to the method of determining validity and some provide validity coefficients.

b. Reliability.—Reliability is the consistency with which a test measures that which it does measure; like validity, it is determined numerically by the statistical device of correlation. Valid tests may be considered reliable, although reliable tests may not be valid. High reliability coefficients may be obtained from "artificial tests." A test may measure consistently and at the same time may not be a measure of any identifiable ability.

There are three commonly used methods for determining reliability.[1] One method is to give the test and repeat it on the same pupils within an optimum length of time, calculating the coefficient of correlation between the two sets of scores. Another method now generally used is to give the test once and correlate the scores on the odd and even numbered items of the test. Since this method provides a coefficient for the two halves of the test, the Spearman-Brown prophecy formula is used as a correction for the whole test. A third method consists in administering two duplicate forms of the test to the same pupils and determining the coefficient of correlation between scores made on the two forms.

The chief disadvantage of the first method is that in administering the test twice there is the possibility of improving scores on the second testing because of previous experience. It is difficult to account for practice and increased knowledge effect when this method is used. The second method although widely employed may be criticized in that each item in the test is considered comparable to every other item. By changing the order of items reliability coefficients may vary for the same

[1] GARRETT, *op. cit.*, Chap. 6.
ODELL, C. W., *Educational Statistics*, New York, Century, 1925, Chap. 5.

test. Its chief advantage is its elimination of "carry over" effect present in the first method and the time and effort saved in administering the test only once. When it is possible to obtain two equivalent forms of the same test, the method of correlating scores on two duplicate forms is desirable.

Reliability is influenced by many factors, chief among which is objectivity. One of the chief reasons why the standardized test is more reliable than the essay examination is its objectivity in scoring. When questions permit of variations in answers, there necessarily results a variable error which produces inconsistency in performance. The length of the test is also an important factor. Standardized tests having few items are likely to have low reliability. Few items provide little opportunity for wide sampling of material. Reliability is increased within limits with increase in the number of items. Items which are arranged in order of difficulty as determined by percentage of success or probable error locations favorably affect reliability. It is also influenced by validity of source and function. When invalid items are eliminated on the basis of inside criteria, reliability is perceptibly increased. These and many other factors are usually taken into account in determining the reliability of tests.

Reliability coefficients are expressed in various ways although calculated by the correlation device. If determined by the optimum interval method they are usually expressed as $r12$; if by the odd and even method, $r\frac{1}{2}\ \frac{1}{2}$; or if by the method of duplicate forms, rAB. Reliability coefficients as high as 0.75 or 0.80 may be considered satisfactory for the group, but should be approximately 0.90 or more if it is desired to make estimates for individuals.

Reliability coefficients are of the greatest significance, and, although there has been an attempt to construct tests with coefficients sufficiently high to diagnose and predict pupil ability accurately, the majority of tests are satisfactory only for the group. Tests should have reliability coefficients sufficiently high to insure stability of an individual's score. The reliability of a pupil's score is statistically determined by

the probable error (P.E. of score), which indicates the extent of its probable variation. The higher the coefficient, the less likely is the individual's score to vary. Probable errors are also calculated for the reliability coefficient and furnish a check on the adequacy of sampling. Again, the higher the reliability coefficient and the smaller the probable error, the greater the likelihood of stability of scores for the group as a whole and for individuals. Reliability coefficients are usually provided in the manuals of instructions accompanying tests, and in some cases coefficients are provided for various parts of the test. Tests should be examined not only for their degree of reliability, but for methods of determining reliability.

Reliability varies with different subjects and fields. In general, subjects and fields which lend themselves to measurement of factual information and specific abilities are likely to have higher reliability than those which deal with abstractions and intangible qualities. Reliability is sometimes emphasized at the expense of validity. However, the two are so closely related that one cannot properly be considered without the other.

c. Objectivity.—Two phases of objectivity should be considered: objectivity in scoring and objectivity in construction. Attention is usually directed to objectivity in scoring, which implies a standardized scoring device intended to minimize personal opinion. Objectivity in scoring thus affects both reliability and validity. If a test does not lend itself to uniform methods of scoring, there will be a resultant variability in performance, thus decreasing consistency which is essential to reliability. Since reliability varies with validity of source and function, objectivity influences validity. It is probable that the most outstanding single contribution of standardized tests is their objectivity in scoring, which provides an impartial score for pupil performance.

Less attention has been directed to objectivity[1] in con-

[1] The need for emphasis upon objectivity in constructing questions has been forcefully brought to the writer's attention by Cecil B. Read of Wichita University.

structing the questions themselves. By objectivity of construction is meant that there is not more than one possible interpretation of each question. Some true and false questions may properly be answered as neither true nor false, because the questions may be true under some circumstances and false under others. Again, questions may be usually true but not always. Questions should, therefore. be carefully evaluated for their objectivity in meaning.

d. Discrimination.—Discrimination refers to the extent to which a test distinguishes among various degrees of ability. As has already been noted in determining validity of function according to the method of inside criteria, a test should be so constructed that pupils who are in the highest quarter on the total test should pass various items with a larger percentage of success than those in the lower quarters. Discrimination is also determined by the degree to which the scores on a test conform to normal probability. If the test scores group themselves toward the lower end of a frequency distribution, it is assumed that the test is too difficult; if they center around the upper end of the distribution, the test is too easy. A test, when constructed for several ages and grades, should also indicate corresponding growth in ability as pupils become older and educationally more mature. Pupils who are thirteen years of age should make higher scores than those who are twelve, and pupils in the seventh grade should generally make higher scores than those in the sixth grade.

e. Norms.—Norms are expressed in terms of typical performance for the grade or age level considered, and are sometimes expressed in terms of racial and social groups. Norms should be stable and representative of the group with whom it is desirable to make comparisons. They should be reported in full and are more useful when both universal and local. Since norms represent average performance for representative pupils, they should be interpreted with caution. Teachers are interested in comparing their pupils whith those upon whom norms have been established, and are particularly desirous in having their pupils reach the norm. However, available norms

are based upon average results of prevailing practice, and it is quite possible that such norms will move up as revised aims, scientific methods and appropriate materials make themselves felt. Because norms are measures of the average achievement of representative groups, they should be used as reference points rather than as aims or standards.

Some investigators, in addition to supplying norms for various ages and grades as expressed in terms of central tendencies and deviations, furnish percentile norms and other means of comparison. The pupil is considered as inferior, normal or superior according to the position of his score in the total distribution upon which the test was standardized. Thus, it may be said that the pupil's score is equivalent to that of the upper 10 per cent or any other position in the distribution. One should, in examining norms, especially search for a statement of the number of pupils upon whom the test was standardized rather than the number of pupils who have taken the test after the standardization process. Pupils used in the standardizing process are the important criteria because it is they who have made possible the inclusion of various items of the test. The average number of cases used in the standardization of educational tests is approximately 500. Whether this is a sufficient number depends among other things upon the representativeness of the group and the extent to which the norms vary with increase in the number of cases. When it is found that the inclusion of additional cases appears not to affect the stability of means or medians and their probable errors, norms may be considered satisfactory. Norms should be interpreted in terms of their probable errors[1] so that a critical evaluation may be made.

Tests should, in addition to the foregoing criteria, be examined for their adaptability to the various ages and grades to be measured, the number and types of questions, their interest and motivating devices. Tests should also provide duplicate

[1] For a discussion of the significance of probable errors in relation to means and medians, see L. L. Thurstone, *Fundamentals of Statistics*, New York, Macmillan, 1925, Chap. 21.

forms so that progress may be determined. Instructions should be brief as is consistent with understanding and should have demonstration exercises. Instructions to pupils should be accompanied by instructions to examiners, and should clearly demonstrate the method of scoring and interpreting scores. Other factors include date of publication, author and price.

2. Methods of Expressing and Interpreting Test Scores. The test having been selected and administered, the next step is to score it and statistically express its results so that they may be interpreted. In expressing test scores several methods are used.

a. Central Tendencies and Deviations.—The results of some tests are expressed only in terms of central tendencies and deviations. In such cases a frequency distribution is constructed and one or more measures of central tendency and deviation are computed. Most tests supply norms which are expressed in terms of means or medians and quartiles so that the efficiency of any pupil or group for any grade or age may be determined by comparing it with the norm. In such a case raw scores have significance only when compared with the norm for the test. Usually a pupil is considered normal when his score is within the middle 50 per cent of cases as shown by the norm. Some tests also provide percentile scores and percentile ranks, and the pupil's score is expressed either in terms of his standing in relation to the group of which he is a part or the group upon which the test is standardized.

Test scores are also expressed in terms of subject ages, educational ages, subject quotients, educational quotients, mental ages, intelligence quotients and achievement quotients.

b. Subject Ages.—The subject age is the score expressed in terms of chronological years and months for individual school subjects. For example, a subject age of 7-4 represents the performance of the average child who is seven years and four months old. Figure 20 shows the median subject ages, according to types of schools, for the third grade. These results are based upon the Primary form of the New Stanford Achievement Test, which includes measurement in three fundamental sub-

jects, there being two phases respectively of reading and arithmetic. Figure 20 reveals the following facts: (1) In grade 3 all schools, regardless of type, are below the norm in "paragraph meaning" and "word meaning." The consolidated schools are normal in "dictation," and all types of schools are normal in both phases of arithmetic. (2) The one-teacher schools are far below the other types of schools in "paragraph meaning" and "dictation" and are equal to all types of schools in "arith-

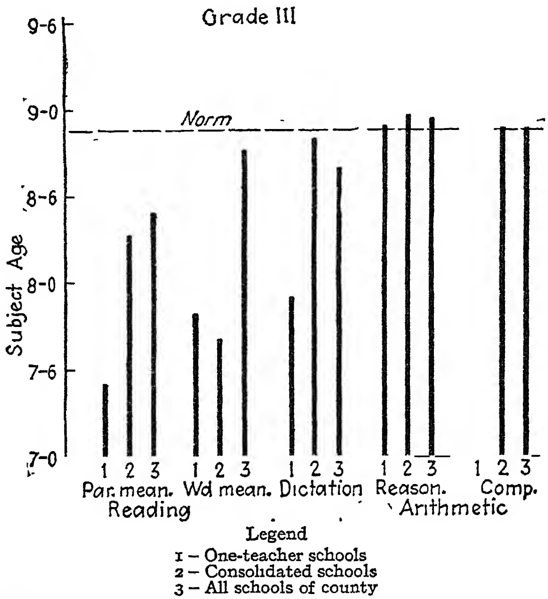
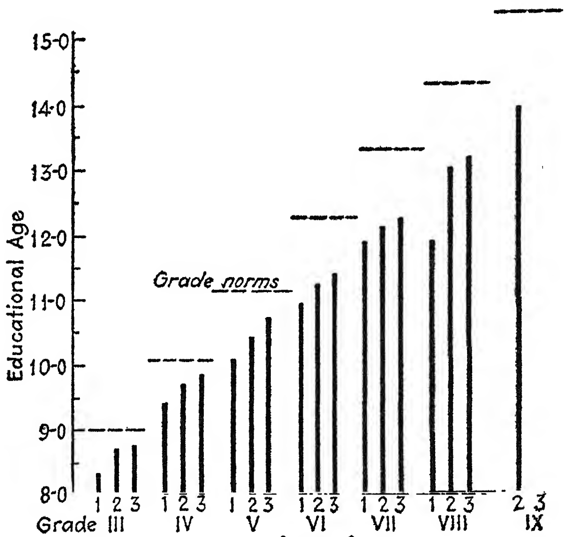


FIG. 20.—Median subject ages of pupils on the New Stanford Primary Achievement Test according to types of schools.

metical reasoning" and "computation." The median subject ages show that the pupils are lowest in reading and dictation and highest in arithmetic. It is evident that there is much remedial work needed in both "paragraph meaning" and "word meaning."

c. Educational Ages.—The educational age is more significant than the subject age because it is the average of the individual subjects or fields. The educational age is the average of the subject ages as expressed in terms of chronological years and

months. For example an educational age of eleven years and two months means that the pupil is doing work equivalent to the average child who is eleven years and two months old. The educational ages derived from the Primary and Advanced New Stanford Achievement Tests are presented together in Fig. 21. Educational ages when distributed by grades show in a general way the weak and strong points in the achievement of a school. Such distributions show wide variations in the



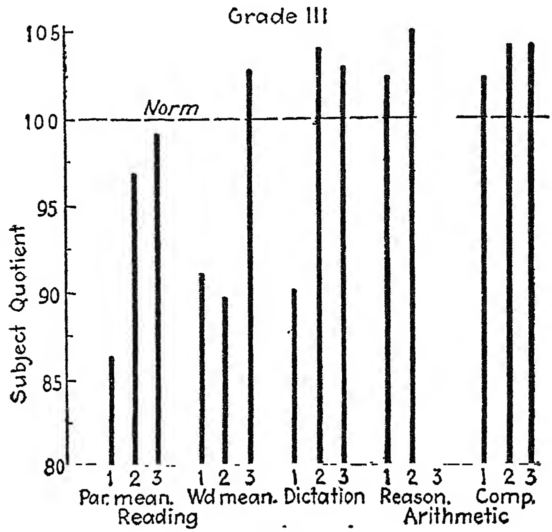
Legend
1 – One-teacher schools
2 – Consolidated schools
3 – All schools of county

FIG. 21.—The median educational ages of pupils on the New Stanford Primary and Advanced Achievement Tests, according to grades and types of schools.

achievement of pupils in the same grade. With such wide variations in achievement for various grades it is impossible to teach all pupils with the same degree of effectiveness. The significant feature of Fig. 21 is that in all grades and all schools pupils are appreciably below the norm. One-teacher schools are lower in all grades than other types of schools. The discrepancy between the norms and actual achievement is greater for the upper than for the lower grades, which indicates that

the schools of the county are doing their best work in the lower grades.

d. Subject Quotients.—The subject quotient is significant in that it is the ratio of the subject age to chronological age and is expressed thus: Subject quotient = S.A./C.A. If a pupil is doing normal work for his age, his subject quotient will be 100, which indicates that he is doing work equivalent to the average



Legend
1 – One-teacher schools
2 – Consolidated schools
3 – All schools of county

FIG. 22.—Median subject quotients on New Stanford Primary Achievement Test according to types of schools.

child of his age. The subject quotients above 100 indicate more than average work for one's age, while those below 100 indicate less than normal. The median subject quotients derived from the use of the primary form of the New Stanford Achievement Test in grade 3 for types of schools are found in Fig. 22. It is shown that the subject quotients for grade 3 are for the most part up to or above the norm in "dictation," "arithmetical reasoning" and "computation," while perceptibly below the norm in "reading." One-teacher schools

are below other types of schools in "paragraph meaning," "dictation," "arithmetical reasoning" and "computation."

e. Educational Quotients.—The educational quotient is the ratio of the pupil's educational age to his chronological age. To derive the educational quotient divide the E.A. by the C.A. thus: E.Q. = E.A./C.A. The educational quotient is a measure of what the school has done for a child of any given age. Since the variation of achievement expressed in terms of age is

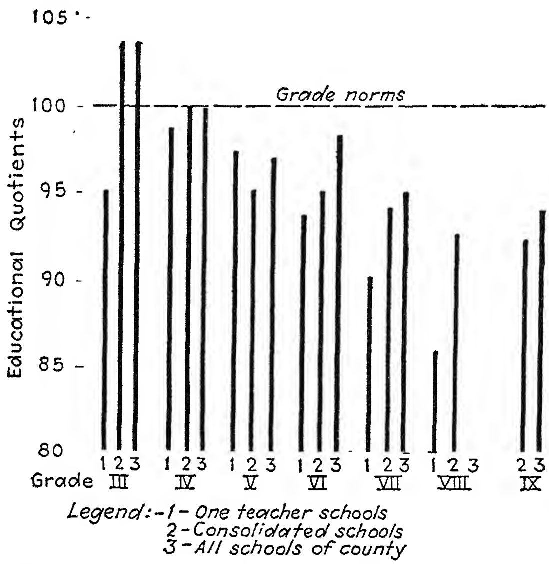


FIG. 23.—Median educational quotients of pupils on New Stanford Primary and Advanced Achievement Tests according to grade and type of school.

less for different communities and states than that of achievement in grade position, it is evident that the educational quotient is a more reliable measure than any instrument expressed in terms of grade values. The normal educational quotient for any unselected group of any age is 100. Figure 23 reveals that only a few educational quotients for any school or any grade are up to normal according to the Stanford Tests, the majority of the quotients being in the nineties. The average of the median educational quotients for all grades in the one-teacher schools is 95. The average for the consolidated

schools is 96, while the average for the all-schools-of-the-county group is 97.

f. The Mental Age and Intelligence Quotient.—The mental age is a valuable measure of intelligence because it is used as a standard of mental maturity for purposes of classification. The mental age is a pupil's score on a general intelligence test, interpreted in terms of chronological age. To say that a pupil has a mental age of 10-0 means that the pupil is equal in ability to the average child who is ten years old. The mental age is, therefore, a measure of mental maturity and does not indicate in itself the degree of brightness. It is only when the pupil's mental age is compared with his own chronological age that his degree of superiority or subnormality is determined.

The intelligence quotient marks the degree of brightness and is obtained by dividing the mental age by chronological age. Intelligence quotients between 90 and 110 are usually considered "normal," those above 110, "superior," and those below 90, "inferior." Since the intelligence quotient remains relatively constant, it may be used as a basis for determining the rapidity with which the pupil may be expected to progress through the school system. Children of low intelligence quotients cannot be expected to progress as rapidly as brighter children. For classes consisting of lower intelligence quotients a longer time should be allowed for the completion of the course of study; for pupils having intelligence quotients within the normal range the average rate of progress may be expected; while for the higher sections possibly a shorter time should be allowed for the completion of the work. For pupils of low intelligence quotients the minimum essentials of the tool subjects should be conducted at a slower pace with frequent repetitions. For the higher sections the work in the traditional subjects may be shortened and the curricula enriched by wide reading, individual projects and conferences.

A further use of the intelligence quotient is found in the problem of educational and vocational guidance. Pupils having intelligence quotients of 110 or above are able to profit by a college education and are capable of entering the so-called

professional fields. Those below 90 are able to go through the elementary schools with a fair degree of success and are capable of succeeding better in the unskilled, semi-skilled and skilled labor occupations.[1] However, the impression should not be left that children of inferior intelligence are doomed to lives of failure. Studies have conclusively shown that children of the dull and border-line intelligence levels are capable of successfully holding jobs and positions in which their subnormality is no handicap. Many of these children succeed in some jobs and positions even better than do those favored with higher intelligence. The real problem is training children in types of occupations which are commensurate with their intelligence, interests and vocational aptitudes.

g. Achievement Quotients.—The accomplishment quotient is used to show the relationship between a pupil's achievement in various subjects and his ability to do schoolwork. It is found by dividing the educational quotient by the intelligence quotient, as E.Q./I.Q. The achievement quotient may also be computed for any subject by dividing the subject age by mental age. As generally interpreted, the theoretical norm for any pupil is 100.

There are some teachers whose pupils are achieving more than the average as determined by the results of a standardized test; others have pupils working far below the average. It is relatively easy for any teacher to obtain superior results with a group of bright pupils. There can be no evaluation of teaching efficiency until the mental abilities of these groups have been determined.

Toops and Symonds[2] refer to the achievement quotient as a measure for combining effectively the results of educational and mental tests into a measure of achievement relative to the pupil's capacity to learn. Stebbens[3] believes that the achieve-

[1] DAVIS, ROBERT A., The need for guidance in orphan homes, *Elem. School J.*, 1929, 19, 51–55.

[2] TOOPS, H. A., and P. M. SYMONDS, What shall we expect of the A.Q.? *J. Educ. Psychol.*, 1922, 13, 513–515; 1923, 14, 27–28.

[3] STEBBENS, R. C., Accomplishment quotients as an aid in diagnosis, *Elem. School J*, 1929, 8, 382–392.

ment quotient is the fairest and most valuable measure of the efficiency of both teacher and pupil because it evokes from pupils and teachers results which are in proportion to the native ability of pupils. McPhail[1] notes that bright pupils are less apt to work in accordance with capacity than the dull and that the dull child achieves more than is expected when capacity is taken into account. Several investigators have noted the negative correlation which usually exists between intelligence quotient and achievement quotient and have suggested various explanations. Wilson[2] believes that the negative correlation is due to spurious factors which enter into the computation of quotients as well as to the unreliability of tests upon which the achievement quotient is based and to the fact that intelligence is not the sole determinant of achievement. Torgerson and Shuman[3] suggest that the negative correlation may partially be due to improper classification. Goodenough[4] states that learning is a function of time as well as ability and that a child with a mental age above the norm for his grade does not have opportunity to acquire enough information to raise his achievement quotient to the desired level; this implies that most classes are taught for the average pupil.

The accomplishment quotient has gained recognition chiefly on the ground that it is an effective measure of the relation between ability and achievement. If the achievement quotient fulfills the requirements of a desirable instrument, effort should be made to eliminate its objectionable features. Some objections may be overcome by refining the measures of intelligence and achievement; others may be eliminated by training teachers in the proper use of standardized tests. In addition two other obstacles which are inherent in the technique should be corrected. One disadvantage is the spurious element entering

[1] McPhail, A. H., Correlation between I.Q. and A.Q., *School & Soc.*, 1922 16, 586–588.

[2] Wilson, W. R., The misleading A.Q., *J. Educ. Res.* 1928, 17, 1–10.

[3] Torgerson, T. L., and Irene Shuman, Variability in accomplishment of pupils of the same mental age, *J. Educ. Res.*, 1925, 11, 132–136.

[4] Goodenough, F. L., The efficiency of learning and the accomplishment ratio, *J. Educ. Res.*, 1925, 12, 297–300.

into the computation of quotients and the other is the fact that the achievement quotient must take into account mental age and rate of mental growth in relation to level of instruction. It is not proposed[1] to obviate these difficulties, but to suggest a more valid means of comparing the achievement quotients of individuals with those of the group.

Since the usual technique yields an expected accomplishment quotient too high for bright pupils and too low for those who are dull, the proposed method operates to make the expected achievement quotient dependent upon the capacity and achievement of the group rather than upon some theoretical norm. Thus bright pupils will be expected to have accomplishment quotients of less than 100 while dull pupils will be expected to have those of more than 100. The expected achievement quotient may be computed from a regression line of intelligence quotient on achievement quotient. The intelligence quotients and achievement quotients are determined in the usual manner. The index of achievement may then be found by subtracting the actual achievement quotient from the expected achievement quotient. Obviously by this procedure the expected achievement quotients for different groups will vary, the amount of variation depending upon average ability and achievement. In order to study the actual A.Q.-expected–A.Q.-procedure, tests were administered to 395 children of the sixth grade in 15 schools in northern Pennsylvania. To determine the intelligence quotient, the Haggerty Intelligence Examination Delta 2 was used, and to determine the educational quotient the New Stanford Achievement Test, Form V, was employed.

Since the accomplishment-quotient technique operates to raise spuriously[2] the achievement quotients of those below average intelligence and lower those above average intelligence, but does not affect perceptibly those approximating the average, this method applies particularly to those cases of

[1] Davis, Robert A., and W. A. Campbell, A more valid method of comparing the accomplishment quotients of individual pupils with those of the group, *J. Appl. Psychol.*, 1934, 18, 272–281.

[2] Rogers, K. H., Intelligence and perseveration related to school achievement, *J. Exper. Educ.* 1933, 2, 35–43.

extreme ability which are most likely to be affected by any defect in the quotient technique. The actual achievement quotients are those found in the usual manner, while the term *expected A.Q.* as used here means those values found by regression of intelligence quotient on achievement quotient. This regression line is found from the correlation between intelligence quotient and the actual achievement quotient and is plotted on the scatter diagram from which the correlation was originally computed.

According to the usual achievement-quotient procedure, the theoretical ideal value for any intelligence quotient would be 100. By means of the regression line, the expected value for any intelligence quotient will vary and will not be a fixed norm. This value will vary according to the mean intelligence quotient and mean actual achievement quotient of the group, and will also take into account the correlation between the intelligence quotient and achievement quotient and the variability of the two measures. In other words the expected achievement quotient for any given intelligence quotient will be based upon the measures of intelligence quotient and achievement quotient and not upon some arbitrary value. Thus the expected achievement quotient for any pupil is found in reference to the ability and accomplishment of the group. It will

TABLE 36.—THE EXPECTED A.Q.'S FOR VARIOUS LEVELS OF INTELLIGENCE

I.Q.	Expected A.Q.
160	84
150	87
140	89
130	91
120	94
110	96
100	99
90	101
80	104
70	106
60	109
50	111

be in terms of what is expected of him under conditions of group ability and achievement. The regression line of intelligence quotient on achievement quotient for the group under consideration yields the approximate values for the different levels of intelligence as shown in Table 36.

The middle 50 per cent of cases lies between intelligence quotients of 85 and 110. The expected achievement quotients for this group range from 96 to 103. These facts show that the expected achievement quotient for the group of average intelligence will vary but 3 points on both sides of the theoretical value of 100. The upper 25 per cent in ability ranges from 110 to 160. The corresponding variation in the expected achievement quotient is from 84 to 96, showing a range of minus 12 points under the theoretical value of 100. The lower 25 per cent ranges from 51 to 85 in ability, and varies in expected achievement quotient from 102 to 109, or plus 7 points. These results show that the correction influences the middle 50 per cent by but 3 points on both sides of the ideal value of 100, while the upper 25 per cent is affected by minus 12 points and the lower 25 per cent by plus 7 points. The correction thus influences markedly the expected value of the achievement quotient for pupils at the extremes of intelligence.

These facts show that the actual A.Q.-expected–A.Q.-procedure overcomes certain limitations of the usual achievement-quotient technique. The corrected technique on the face of results obtained operates to afford a more reliable means of comparing the achievement of individuals within a group, when the group as a whole varies widely in intelligence, than was possible under the usual achievement-quotient method. It also affords a more reliable method of comparing the achievement of groups when they vary widely in intelligence than was possible under the usual achievement-quotient technique.

3. Types of Educational Tests. *a. Types According to Construction.*—Standardized educational tests according to construction may be quantitative or qualitative, rate or power tests. Quantitative tests emphasize speed and accuracy, and

efficiency is measured by the number of correct responses within limited time. The score which a pupil makes is thus a quantitative expression of rate and accuracy of performance. The majority of educational tests are quantitative.

Emphasis in qualitative tests is placed primarily upon the quality of performance, which does not necessarily imply accuracy. Most qualitative tests have time limits, but these limits are so liberal that the majority of pupils finish within the allotted time. Qualitative tests are illustrated by English composition scales which furnish several samples of composition ability statistically arranged in order of merit on the basis of competent judges. The pupil's composition is compared with standards of quality and assigned a numerical value. Handwriting scales are developed in a similar manner. The pupil's handwriting is compared with standard samples and assigned a value according to the degree to which his handwriting corresponds with the various samples.

In the construction of qualitative scales, there is the collection of sample performances which represent a wide range of ability and the determination of quantitative descriptions of each sample with reference to an assumed zero point. In such scales the emphasis is clearly upon the quality of English composition and handwriting ability and not upon the number of themes or words written. Since qualitative scales are constructed on the basis of judgments and scored on the basis of opinion, they are not so accurate as quantitative tests.

Rate tests provide exercises of relatively the same difficulty and emphasize speed of performance. For example, rate tests in arithmetic provide examples of approximately the same difficulty; they are used primarily for remedial measures after it is found that pupils are deficient in specific abilities. In general, power tests have no time limit and their exercises are arranged in order of increasing difficulty; the emphasis is clearly upon how far the individual may go on the scale, irrespective of time. The aim is to determine how difficult a problem the pupil can solve. Most tests designed to measure arithmetical reasoning are power tests. Qualitative tests

emphasize power while quantitative tests stress rate and accuracy.

b. Types According to Use.—Tests may be classified according to use as measures of achievement, acquisition, aptitude or potentiality for success in various phases of schoolwork. Achievement tests include diagnostic, survey and instructional tests.

The diagnostic test is used to discover pupil difficulties. Thus a test in arithmetic is diagnostic when it shows the weaknesses of pupils in addition, subtraction, multiplication or division. A test in arithmetic may be still more diagnostic when, for example, it discovers many specific abilities in each of the fundamental processes. A test may also diagnose deficiencies in speed and accuracy. The diagnostic test aims to determine the weak points in the pupil's ability in a particular subject so that remedial measures may be provided. Consequently it is especially useful as a teaching device.

The survey test aims to measure the general level of efficiency and does not attempt to discover individual weakness or strength. For example, a survey test in arithmetic may provide exercises in all of the fundamental processes, and yet not have sufficient exercises in any one phase accurately to diagnose ability. The survey test thus furnishes information which is of more direct value to the superintendent and supervisor than to the teacher.

The instructional test is designed to measure abilities in various units of work in a course or subject. The practice is to administer an instructional test when each unit of work is completed to determine whether pupils have mastered each unit sufficiently well to begin the next. They are usually designed to accompany textbooks or courses of study, and are intended as teaching devices. Generally these tests are only partially standardized.

Aptitude tests are illustrated by prognostic and placement tests. The term *prognostic* is applied to that type of test which is designed to forecast ability. Prognostic tests have been devised in several fields of subject matter, especially for modern

foreign languages and mathematics. In constructing such tests, there is an attempt to determine abilities requisite for success. Their validity is dependent upon the degree to which pupil performance coincides with success in the subject as measured by achievement tests, marks obtained in the subject or other measures. In subjects which show a high percentage of failure, such tests are especially valuable from the standpoint of educational and vocational guidance. Since they forecast ability, they tend to reduce failure. However, prognostic tests so far developed have not been highly satisfactory. The validity coefficients do not usually extend beyond 0.70 or 0.80, which may predict the potentiality of the group, but which are not high enough for individual predictions. Examples of prognostic and placement tests include Rogers's Test of Mathematical Abilities and the Iowa Placement Examinations.

The type of test selected for use will depend upon the need for the occasion. The same type of test may frequently be used for different purposes. The diagnostic test is usually more appropriate for the teacher. The survey test is valuable when a general purview of achievement is desired. Instructional tests are used primarily as teaching devices, while prognostic tests are used chiefly for administrative purposes as a basis for educational and vocational guidance.

4. Uses of Educational Tests.—Tests assist in solving many problems in administration and supervision and are valuable instruments in teaching. In administrative and supervisory activities, tests are used as a basis for classification and sectioning of classes, promotion and educational and vocational guidance. We are concerned primarily with educational tests from the standpoint of their uses as instruments of teaching. Tests may be used in teaching for determining present status or for measuring progress.

a. Determining Present Status.—Tests may be administered to determine the general level of efficiency of a class or to discover specific weakness, either in instruction or ability, as a basis for remedial treatment. Tests may be administered to determine efficiency in several subjects, of a single subject or a specific

phase of a subject. A battery test enables the teacher to obtain in one examination a general purview of achievement in several subjects. Several specific tests may also be used when it is desired to measure different aspects of ability in the same subject. Tests used in this way are primarily for the purpose of diagnosis and do not measure progress or improvement in ability for definite periods of instruction. Some uses of tests may be designated as follows:

1. To determine whether or not a class or school is up to standard.
2. To determine whether individual pupils should be promoted, retarded or reclassified.
3. To furnish a basis for assigning marks.
4. To determine special weaknesses and difficulties of pupils.
5. To furnish a basis for remedial measures.
6. To determine standards of achievement for a class.
7. To determine teaching objectives for the year.
8. To objectify records of performance.
9. To compare one school system with another.
10. To compare schools or classes within the same system.

b. Determining Progress.—Those using educational tests as instruments of teaching have tended to emphasize present status of ability with little stress upon the use of such tests as a basis for measuring progress. It may be of interest to the teacher to know that the average score in her arithmetic class is 24.5 on Oct. 1, and that the pupils are deficient in some specific skills, but it is more important to know how much progress has been made between Oct. 1 and Dec. 1. Educational tests administered once can only serve to diagnose pupil difficulties, indicate weaknesses in the efficiency of instruction and serve as motivating devices for further improvement. They do not specifically show the amount of attainment for definite periods of instruction. Any testing program must in a large measure be continuous. Different forms of the same test should be given at definite periods in order to determine improvement which may be gained from the application of remedial measures. If tests are given as a basis for checking the results of teaching, the attitude of the teacher will be improved since she will have an objective criterion of her own teaching.

Tests used for the purpose of determining progress and the effects of certain teaching devices represent a "before" and "after" condition which is characteristic of the experimental method. Tests given to measure progress should have duplicate forms so that they may be repeated with assurance that there is little practice effect. By measuring pupils in the fall and remeasuring them at the end of various quarters or semesters, the amount of progress may be determined. The difference between the average performance of pupils when measured in October and in December indicates the degree of attainment, which may be compared with norms of achievement for definite periods.

The effectiveness of teaching techniques and of motivating devices may be tested by this procedure. An example[1] of an attempt to test improvement made by pupils taught under two different school systems is shown in Table 37. In one case the pupils are taught mainly by student teachers under supervision, while in the other they are taught by regular

TABLE 37.—THE MEAN GAINS IN READING (EXPRESSED IN TERMS OF CHRONOLOGICAL MONTHS) FOR TRAINING-SCHOOL AND PUBLIC-SCHOOL PUPILS AS MEASURED BY THE NEW STANFORD ACHIEVEMENT TESTS

Grade	School	Mean gains	Difference	E.C.	In favor of
2	T.S. P.S.	17.18 18.40	1.22	0.17	P.S.
3	T.S. P.S.	12 95 5 94	7.01	0.86	T.S.
4	T.S. P.S.	7.49 14.12	6.63	0.91	P.S.
5	T.S. P.S.	13.68 12.87	0.81	0.006	T.S.
6	T.S. P.S.	8 21 5.19	3.02	0.23	T.S.

T.S. = training school
P.S. = public school
E.C. of 1.00 = practical certainty

[1] SEAMSTER, F. C., and ROBERT A. DAVIS, The efficiency of training-school and public-school pupils, *Educ. Admin. & Sup.*, 1931, 17, 224–231.

teachers in the public schools. The pupils from the two groups were first equated on the basis of chronological and pedagogical age and intelligence quotient. It was believed that efficiency of instruction under the two types of schools could best be measured if tests were given early in the school year and followed by duplicate forms of the same tests in the spring. In reading, there were no reliable differences made in the gains of any grade for either type of school. However, in grade 4 there was a difference, the reliability of which, expressed in terms of the experimental coefficient, was 0.91, as large as it should be to indicate practical certainty. This difference was in favor of the public school, while the experimental coefficient in grade 3 was 0.81 in favor of the training school. Examination of the experimental coefficients for each grade shows that the two types of schools reveal greater similarities than differences in reading ability.

This method may be employed to test the effectiveness of special methods of teaching. In geometry one may use tests to determine the effectiveness of analytic and synthetic methods, while in history the efficiency of the unit and lecture method may be compared. The degree of pupil achievement and teaching efficiency can be reliably determined by the use of standardized educational tests administered during various periods of the school year. Some uses of tests for measuring progress are indicated as follows:

1. To determine whether or not a class is making progress.
2. To determine the extent of progress made.
3. To test a class plan or teaching device.
4. To furnish a basis for teacher self-examination and rating.
5. To furnish a basis for remedial measures.
6. To determine a basis for immediate and final objectives of the year.
7. To test the adequacy of teaching methods.
8. To furnish a basis for assigning marks.

B. Objective Classroom Examinations

Standardized educational tests furnish a valuable means for checking efficiency and measure improvement, but they should be supplemented by objective classroom examinations,

which are more adaptable for quizzes, examinations and teaching devices. The difference between objective classroom examinations and standardized educational tests is primarily a difference only in standardization. The two examinations have essentially the same types of questions and exercises, and both are objective. The objective classroom examination emphasizes content peculiar to the particular course or subject, usually with no attempt to evaluate it on the basis of pupil performance. Since the classroom examination is peculiar to the local situation, it is more likely than the standardized test to be valid according to source.

1. Types of Classroom Examinations.—Objective classroom examinations are divided into two general classes[1] which may be designated as recall and recognition. Questions in recall examinations may be answered by one word, a short sentence or by the completion of sentences. The pupil is expected to search out and revive acquired material with the aid of cues. Most recall tests are so constructed that the pupil is aided in his answer by the beginning of a sentence or by words or phrases which require completion. Recognition examinations are so devised that answers are provided and the pupil selects those believed to be correct. The emphasis is primarily upon the ability to recognize and identify answers. Ruch[2] shows that 90 per cent of objective classroom examinations consist of completion, true-false, multiple choice, matching, identification questions and their variants. Completion questions and their variants may be classified under recall while the remainder of these types may be classified as recognition. The following questions based upon the material of this chapter illustrate recall examinations:

1. Recall types.
   a. Simple recall.
      (1) What particular feature has brought the essay-examination into ill repute? *Ans.* subjectivity of scoring.

[1] For a discussion of types of objective examinations, see G. M. Ruch, *The Objective or New Type Examination*, Chicago, Scott, Foresman, 1929.

[2] *Ibid.*

(2) Name two criteria for the establishment of validity of function. *Ans.* outside criteria and inside criteria.
(3) Name three types of tests according to their use. *Ans.* diagnostic, survey, prognostic.

b. Completion.
(1) The (*essay*) examination has fallen into ill repute because of its subjectivity in (*scoring*).
(2) (*Reliability*) is the consistency with which a test measures that which it purports to measure.
(3) Standardized tests should be objective both in (*construction*) and (*scoring*).

c. Short answer types.
(1) Using one sentence define each of the following:
(*a*) Validity
(*b*) Reliability
(2) State briefly in one sentence when each of the following is used to express reliability:
(*a*) r 12
(*b*) $r\frac{1}{2}\ \frac{1}{2}$
(*c*) $r\ AB$
(3) In one sentence state briefly the purpose of each of the following:
(*a*) Diagnostic tests
(*b*) Prognostic tests
(*c*) Survey tests

The following questions based upon the content of this chapter illustrate recognition examinations:

2. Recognition types.
a. True-false type.
(1) ______All tests should be objective in scoring.
(2) ______The essay-examination is more objective in scoring than the new type.
(3) ______Standardized tests may be used to show present conditions or progress.

b. Multiple-choice type.
(1) The reliability coefficient of a test for individual prediction should be
(*a*) 0.75
(*b*) 0.80
(*c*) 0.85
(*d*) 0.90 or above

(2) The type of test used to discover pupil weakness should be
- (*a*) ______prognostic
- (*b*) ______diagnostic
- (*c*) ______survey
- (*d*) ______instructional

(3) The most objectionable feature of the essay examination is its
- (*a*) ______validity
- (*b*) ______objectivity
- (*c*) ______subjectivity
- (*d*) ______reliability

c. Matching exercises.

(1) ______type of test measures recall without cues.	1. Multiple-choice
______type of test measures recognition.	2. Essay type
______type of test measures recall with the aid of cues.	3. True-false
(2) Objectivity of scoring is assisted by means of______	1. Correlation
Standardized tests establish______of	2. Subjective
attainment. Standardized tests are ______in scoring.	3. Central tendencies and deviations
Essay examinations are______in scoring.	4. Key
Norms may be expressed in terms of ______.	5. Norms
Validity may be tested by means of ______.	6. Objective

d. Identification.

(1) Identify the following: *r*; E.A.; I.Q.; E.Q.; A.Q.

(2) Encircle the words that may be applied to the following:

Essay:
examinations, subjective, objective, valid, norms

New-type:
examinations, subjective, objective, valid, norms

Standardized:
examinations, subjective, objective, valid, norms

(3) Encircle the word designating the classification of the following:

Diagnostic tests	construction	use
Composition scales	construction	use
Power tests	construction	use
Prognostic tests	construction	use
Diagnostic tests	construction	use
Handwriting scales	construction	use

The answer in simple recall is composed of one or more words not organized into a sentence. The completion type is usually expressed in the form of a sentence or sentences with several blanks or missing words to be supplied. The short-answer type consists of a briefly worded sentence. The true-false examination provides a sentence and the pupil is required to judge whether it is true or false. In multiple-choice questions plausible answers are provided and the pupil indicates those he believes to be correct. With this type, questions are so arranged that the pupil is required to check one or more answers. For the matching test a set of facts is given with corresponding answers and the pupil matches the facts of the statements with the answers. In the identification type the pupil is expected to identify appropriate answers by checking, encircling or a complete statement. Rules for constructing and scoring these tests may be found in any standard text on new-type examinations.

It has been assumed that recall tests place emphasis upon the acquisition of factual information while recognition examinations stress problem-solving ability and reasoning. Although neither of these claims has been experimentally verified, it is certain that the two types of tests measure different aspects of ability. Consequently, every examination should include both recall and recognition questions. However, even when objective examinations include both recall and recognition questions, there are other abilities which should be considered in measuring achievement. There is the ability to organize material, to discriminate, to express oneself in good English and to make useful applications which can be measured only by the traditional examination. For that reason the traditional examination should be used to supplement objective tests.

2. Improvement of Classroom Examinations.—The literature dealing with objective classroom examinations has dealt mainly with the form[1] of their construction rather than upon their use as instruments for measuring the extent to

[1] Tyler, Ralph W., Formulating objectives for tests, *Educ. Res. Bull.*, 1933, 12, 197–206.

which objectives formulated for subjects have been attained. This condition is unfortunate because, if tests are to measure progress, they should be made with a view to determining the extent to which pupils are realizing objectives formulated for subjects. Each subject is taught for the purpose of producing desirable changes in pupils. The majority of objective examinations, even when skillfully constructed, measure primarily factual information acquired in the subject and do not necessarily measure the extent to which pupils have achieved the objectives established.

In high-school sociology the objectives may be to make students familiar with social agencies and their functions, social theory and its implications and the ability to solve social problems. A comprehensive examination in such a course would necessarily measure factual information about social agencies and social theory and include ability to solve social problems. English objectives may be to develop ability to detect grammatical errors and to learn rules of grammar, to write meritorious compositions and to evaluate and appreciate good literature. Examinations to measure such abilities will include tests which measure the ability to detect grammatical errors and give rules, to write effective themes and to appreciate and evaluate good literature.

Chemistry objectives include the acquisition of a large fund of facts and principles, an adequate understanding of technical vocabulary, the ability to apply chemical principles in practical situations, to formulate equations and formulas and to demonstrate skill in the laboratory. Examinations intended to measure these objectives will involve tests which measure the objectives established in chemistry. In a similar manner each subject has objectives which it is desired that students will attain. Since standardized educational tests cannot easily be adapted to the various objectives formulated by different teachers, objective classroom examinations afford an adaptable means for determining their accomplishment.

Several steps are involved in establishing objectives in subjects. It is first desirable to determine the major topics

in the subject, which may be accomplished by analyzing the content of several or all of the leading textbooks and collateral readings in a field. Such an analysis aids the teacher in formulating clearly the basic material of the subject to be taught. Analysis of content having been made, the teacher may formulate objectives in terms of pupil behavior. Broad, general objectives may first be established and supplemented by many specific objectives. If objectives are stated only in broad generalizations, they are difficult to attain. The specific objectives may be stated in such definite terms that they afford a tangible basis for study. Thus tests may be devised which measure the extent to which both the major and specific objectives have been attained. The broad objectives are usually stated in terms of understandings, attitudes and appreciations, while the specific objectives are stated in terms of habits and skills, which because of their definiteness are more easily measured.

Classroom examinations, to achieve the best results, should partially be standardized. After an examination has been constructed and administered, validity of function may be determined by the method of inside criteria. Items in the examination, which on the basis of pupil response are too easy or too difficult, or which do not discriminate among abilities in the class, should be discarded. The assumption has been that, since the teacher selects items from textbooks, readings and class discussions, the classroom examination is valid according to source and consequently valid according to function. However, it is rare that objective examinations are highly reliable and valid until they have been statistically evaluated. After validity has been functionally established according to the method of inside criteria, the reliability of the test may be determined by the method of correlating odd- and even-numbered items. By eliminating undesirable items through the validation process, the reliability of the test will be increased. Discrimination may also be determined in the same manner as it is accomplished in standardized tests. By making the examination much longer than is needed for one testing,

duplicate forms may be provided by using the odd-numbered items for one form and the even-numbered items for another.

Although objective classroom examinations have higher reliability than essay examinations, even when the essay examinations have been made partly objective, they may be made even more reliable by evaluating them on the basis of statistical criteria. Since they may be given several times, especially when there are duplicate forms, the extra effort used in their partial standardization is compensated for by their continued use.

A formulation of the objectives of every course and a list of the desirable outcomes for the student in gaining those objectives are necessary to make marks as nearly scientific as possible. If classroom examinations are made for brief intervals of the course, the teacher will have several results on which to base his estimate of accomplishment. The accomplishment should then be tempered with the results secured from the daily work of the student. In that manner a raw-score final mark would be established which should be relatively rated on the basis of a curve, standard for the school, and applied by statistical measures. As has been suggested by Billett,[1] there are two objective devices which provide a sound basis for examining and distributing marks. These devices are objective examinations and the normal distribution curve.

C. Summary

Standardized educational tests and objective classroom examinations furnish two valuable means for measuring achievement. Interest in measurement is centered chiefly in the evaluation and use of standardized educational tests and the construction of objective classroom examinations.

Criteria used in the evaluation of standardized educational tests include validity, reliability, objectivity, discrimination and norms. Test scores are usually expressed in terms of central tendencies and deviations, subject and educational ages,

[1] Billett, R. O., Scientific supervision of teachers' marks, *Amer. School Bd. J.* June, 1927, 53–54.

subject and educational quotients, mental ages, intelligence quotients and achievement quotients. When properly interpreted these measures are valuable for determining the efficiency of both pupils and teachers.

Standardized educational tests according to construction may be quantitative or qualitative, rate or power tests. Quantitative tests stress both rate and accuracy while qualitative tests emphasize power of performance. Tests according to use may be achievement tests which measure the results of school instruction, or they may be aptitude tests which measure potentiality for achievement. Tests are used either in an administrative and supervisory capacity or as instruments of teaching. For instructional purposes they may be used for determining present status or for determining progress.

Although standardized educational tests furnish valuable means for measuring efficiency, they should be supplemented by objective classroom examinations which are more applicable to the teaching situation. Since objective classroom examinations are constructed by the teacher on the basis of material with which pupils are supposedly familiar, they are likely to be more valid according to source than the standardized test. Objective examinations may be classified as those which measure recognition and those which measure recall. Recognition examinations provide answers, and the student is expected to identify those which are appropriate. Recall examinations usually measure the ability to revive acquired material with the aid of cues.

In order adequately to construct objective examinations, it is necessary that each subject be analyzed into its major and subordinate topics, and both general and specific objectives be formulated. In order to measure progress, tests should be constructed in such a way that they indicate the degree to which these objectives have been attained. To obtain the best results, these examinations should be evaluated for reliability, validity and other criteria so that they may be used with confidence.

CHAPTER XVIII

RELATIONSHIPS OF PHYSICAL AND MENTAL TRAITS

Objective studies show two general trends regarding the influence of physical development upon mental and educational traits. One view is that physical development may be used as a relatively accurate index of mental and educational growth. The other view is that, although there is some relation between physical growth and mental ability, it is not close enough to be more than suggestive. The opinions of several early investigators are indicated in the following statement:[1]

> Porter and Smedley in the United States conclude that the bright children are taller and heavier than the dull. These results are based on the age-grade method of classification. Arnold and Hogue confirm the weight results. Baldwin, using school marks, comes to the same conclusion. On the other hand, Gilbert found no constant relation and West a negative one. Both of these investigators used teachers' estimates of ability as a basis of classification. McDonald, however, using the same method, confirmed the results of Porter.

Although Baldwin[2] claims that physiological age is directly related to educational age, Gates[3] believes that mental age is not definitely associated with physical characteristics. In support of the view of Gates, Terman writes:[4]

> Insofar as the gifted child departs at all from the average on these traits (growth and general health) it is pretty certainly in the other direction, but the fact seems to be that his deviation from the norm on physical traits is in most cases very small indeed in comparison with his deviation in intellectual and volitional traits. Even the slight superiority that he

[1] DEBUSK, B. W., The vital index in development, *Ped. Sem.*, 1917, **24**, 1–18.

[2] BALDWIN, B. T., The relation of mental and physical growth, *J. Educ. Psychol.*, 1922, **13**, 193–203.

[3] GATES, A. I., The nature and educational significance of physical status, and of mental, physiological, social and emotional maturity, *J. Educ. Psychol.*, 1924, **15**, 329–358.

[4] TERMAN, L. M., *Genetic Studies of Genius*, Stanford Univ. Press, 1926.

enjoys with respect to physical equipment may or may not be due primarily to endowment. It might be accounted for mainly if not entirely by such factors as diet, medical care and other environmental influences.

A. Measures of Physiological Growth

In studying the relation between physical and mental maturation,[1] several methods have been employed to measure physical growth. Some investigators have used height and weight as measures of physical growth; several have approached the problem from the standpoint of carpal and dental ages, while others have used such criteria as pubescence and age of sex maturation.

1. Height and Weight.—One of the most frequent methods of measuring physical growth has been by anthropometric measurements of height and weight which may be determined with a high degree of accuracy. When height and weight are used as measures of physical growth and correlated with mental traits, we find conflicting evidence. Baldwin[2] found a significant coefficient of correlation between height and weight and mental age. His results further indicate that pupils physiologically accelerated are also mentally accelerated and that we may generally attribute the mental superiority of girls during the adolescent age to their earlier physiological maturation. Hollingworth[3] also shows that children in the highest percentage of intelligence are usually above average in height and weight, but she finds no causal relationship between these measures. Other investigators have found very little relationship, although most of them have shown that height and weight and intelligence are positively associated.

Of the two measures, height and weight, the latter is much more susceptible to environmental influences such as nutrition, exercise, sanitation and seasonal changes; weight is therefore

[1] For a succint presentation of objective literature dealing with this and the following sections, see Donald G. Paterson, *Physique and Intellect*, New York, Century, 1930.

[2] Baldwin, B. T., Physical growth and school progress, *U. S. Bur. Educ. Bull.* 1914, 10, No. 581.

[3] Hollingworth, Leta S., Studies of physical condition and growth, twenty-third Year Book, *Nat. Soc. Study Educ.*, 1924, 221–237.

less reliable than height as a measure of physical maturity. In fact the overweight child may be intellectually retarded. Children tend to maintain their relative height. A child who is above the average in height for a particular age is likely to be above the average when he reaches full growth, while a child below the norm for his age is likely to remain below the norm throughout life. It may be observed, therefore, that a short child may have reached the same relative proportion in height at any particular age as a taller child. While these measures yield valuable supplementary data, they are not satisfactory gauges of acceleration and retardation of physical growth and do not show at what stage the child is on the way to maturity.

2. **Carpal and Dental Ages.**—The problem of measuring physical growth has also been studied according to carpal and dental ages. The measurement of physiological development by means of x-ray pictures of carpal bones is a method employed by Prescott,[1] Woodrow[2] and Freeman.[3] These investigators have attempted to show by objective means a measure of anatomic index which takes into account the size of the individual. Prescott determined the anatomic index by dividing the sum of the diameters of all the carpal bones of one hand by the diameter of the wrist. Skeletal development is considered as an index of anatomical age and the carpal bones as measures of skeletal growth. Hence there has developed the use of the term *carpal age.*

This measure of maturity has been favorably received from the standpoint of its use in the research laboratory but, because of the cost of equipment and the specialized requirements of those who operate x-ray machines, it is not likely that it will ever be extensively used in the schools. When the anatomic index is correlated with mental and educational ages, there is

[1] Prescott, D. A., *The Determination of Anatomic Age in School Children and Its Relation to Mental Development,* Harvard Univ. Press, 1923.

[2] Woodrow, H., and F. Lowell, Some data on anatomical age and its relation to intelligence, *Ped. Sem.,* 1922, 19, 1–15.

[3] Freeman, F. N., and T. M. Carter, A new measure of the development of carpal bones and its relation to physical and mental development, *J Educ. Psychol.,* 1924, 15, 257–270.

usually a positive, though not high, relationship. Although it is superior to height and weight as a measure of maturity, when used alone carpal age is not highly predictive of either physical or mental maturation.

Bean,[1] Beik,[2] Cattell[3] and others have used the eruption of teeth as an index to physical and mental growth. Cattell has suggested that the period of eruption of the child's permanent teeth, with the exception of some molars, begins as the child enters school and continues throughout the elementary-school period, and that at any stage in the life of the young child it may be predicted what proportion of the total growth has taken place. The method is objective because the tooth has erupted or it has not, and such a measure if found significant would be convenient for purposes of classification. Cattell shows that dental age is of some consequence as a measure of physical maturity, but the coefficients of correlation between it and mental age are usually too low to justify its use for more than supplementary purposes.

3. Pubescence and Age of Sex Maturation.—Crampton,[4] Baldwin[5] and Godin[6] believe that pubescence is an important criterion of physical and mental maturity. Crampton has devised a method of measuring maturity on the basis of the condition and growth of the hair over the pubic bone, and has advocated the classification of pupils on the basis of those who are prepubescent, pubescent and post pubescent, depending upon the degree of sex maturation. These investigators have amassed much evidence to show that pubescence is a significant criterion of physical and intellectual maturity, but the method cannot conveniently be employed in the schools.

[1] BEAN, B. R., Eruption of teeth as a physiological standard for testing development, *Ped. Sem.*, 1914, **21**, 596.

[2] BEIK, A. K., Physiological age and school entrance, *Ped Sem.*, 1913, **20**, 277.

[3] CATTELL, P., *Dentition as a Measure of Maturity*, Harvard Univ. Press, 1928.

[4] CRAMPTON, C. W., Physical age, a fundamental principle, *Amer. Phys. Educ. Rev.*, 1908, **13**.

[5] BALDWIN, B. T., Physiological growth of children from birth to maturity, *Studies in child welfare, State Univ. of Iowa*, 1921, **1**.

[6] GODIN, PAUL, *Growth during School Age*, Boston, Gorham Press, 1920.

The problem has been further studied by an analysis of children who deviate markedly from the average in the age of sex maturation. By studying individuals who represent the extremes, it was believed that valuable evidence might be produced on the relation between physical status and intelligence. Abernathy[1] made a study of two groups of girls who differed widely in the age at which they menstruated—those who were physiologically retarded and those who were accelerated. The groups were compared in terms of intelligence, grade location, class standing, social development and general health. Her findings show that the age of maturing has some bearing upon these traits but no causal relationship was found between mental and physiological age.

The results, whether we take height and weight, carpal and dental ages or pubescence as measures of maturity, are not significantly different. When correlations between these ages and mental development are computed, it is found that the coefficients are positive, but whether they are high enough to be significant is still questionable. These measures are to some extent indicative of intellectual maturation but cannot be used alone for predicting growth and limits of intelligence and achievement. By combining the various measures and incorporating others not yet discovered, it seems that a composite index might be developed which would be a valuable criterion of physiological maturation. Numerous studies have been based upon the assumption that final limits of physical and mental development can be predicted for a child at an early age, but as yet no investigations have extended over a sufficiently long period to justify definite conclusions. An approach to test the validity of this assumption should trace the physical, mental and educational growth of the same children from childhood through adolescence. Baldwin has developed curves for a limited number of children for several years and the Harvard Growth Study conducted by Dearborn will yield reliable data relating to many phases of mental and educational growth. The development

[1] ABERNATHY, ETHEL M., Correlation of mental and physical growth, *J. Educ. Psychol.*, 1925, 16, 458–466.

and limits of physical and mental traits can be reliably determined only by repeated measurements of the same group of children.

4. The Influence of the Glands.—Experiments in recent years conducted with the endocrine glands and the sympathetic nervous system have suggested a new approach to the study of physical, intellectual and emotional traits. It has been held, for example, that the sympathetic nervous system is the center of subconscious life, that character and temperament are dependent upon the functioning of hormones of some internal glands and that the thyroid gland affects intelligence.

The term *hormone* is used to name the products of internal secretion of the endocrine glands and includes the thyroid, suprarenal, parathyroids, thymus, gonads, hypophysis and epiphysis, which affect physiological reactions. These physiological reactions have been grouped according to those which affect the morphogenesis of the body, those which regulate metabolism and those which control the nervous reactions. If metabolism and nervous reactions are conditioned by the endocrine system, then it follows that intelligence, bodily development and temperament are influenced by the particular functioning of this system.

Pende[1] is responsible for the hypothesis that the same hormones which assist in development of the skeleton and muscles are responsible for the development of the sensory and motor centers, and he suggests that there is a relationship between morphological development and intelligence. Naccarrati[2] has also shown the influence that morphological development has in producing psychoneurosis. Among the different hormones there appears to be a functional relationship, some hormones functioning as a mutual aid, others as reciprocal inhibitions, making for what is known as "interhormonic equilibrium." Variation in the equilibrium to the advantage of one or another group of hormones is responsible for differences

[1] NACCARRATI, S., Hormones and intelligence, *J. Appl. Psychol.*, 1922, 3, 221.

[2] NACCARRATI, S., The morphological aspect of intelligence, *Arch. Psychol.*, 1921, 45, No. 44.

in development and behavior. Naccarrati found a positive correlation between intelligence and the morphologic index, and also a ratio of height and weight and intelligence.

Although the glands as factors influencing physical and mental growth suggest possibilities of far-reaching importance to psychology and education, the findings in this field are still in the experimental stage.

5. The Growth Curve.—The most significant fact about physical and mental traits is their growth with age. Irrespective of the method of measurement or the traits considered, there are within limits increases in ability as children become older. For example, we may expect children to be taller at eight years of age than at seven, and to have higher educational and mental ages as they pass from lower to higher chronological ages. The growth curve shows increase in the amount of traits with increase in age, and may be constructed to depict growth in any traits which have been measured. For the most part they have been constructed on the basis of measurements made of different groups of children rather than of repeated measurements of the same children for a period of years. Baldwin's curve in Fig. 24, which is based upon repeated measurements of a limited number of the same pupils over a period of eleven years, gives a general idea of the growth process in physical and mental traits.

When the same children have been measured on the same traits for several years, the curves tend to show a straight-line relationship. Since curves are usually based upon groups, the marked fluctuations which are characteristic of individuals are not observed. With each additional year in age there is a corresponding increase in physical and mental ability, although it is still debatable when the limits of growth for any trait are definitely reached. Most curves do not extend beyond sixteen or eighteen years of age and we are not sure how much additional growth may be expected in the years beyond these limits. In the case of physical traits such as height, dental and carpal ages, it is probable that the maximum growth has been reached by the age of eighteen years, although indi-

vidual cases may show marked variations in this respect. Most investigations show that the limits of mental growth, as revealed by intelligence tests and expressed in terms of mental ages, are reached by the age of sixteen, while it is conceivable that educational age, as measured by standardized achievement tests, may increase through the college period.

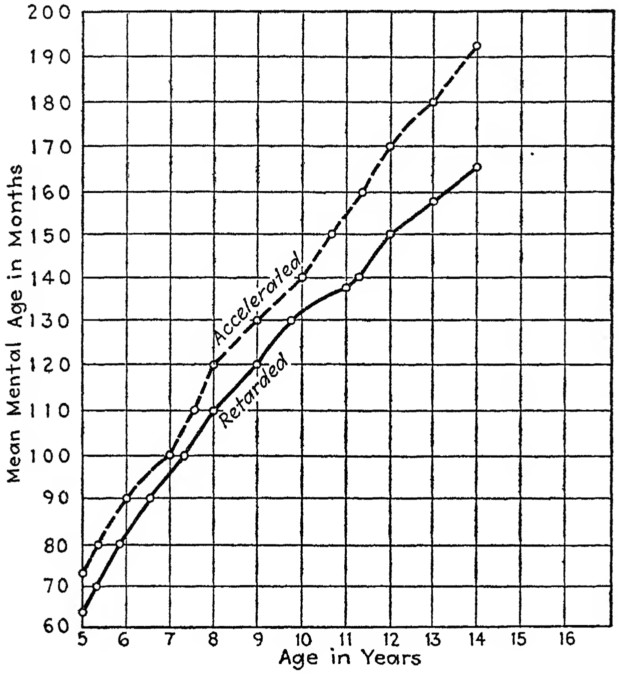


FIG. 24.—Mean mental age in months of physiologically accelerated and retarded boys. (*After Baldwin and Stecher*, 1922.)

It was once believed that mental maturity was reached with sex maturation, which placed the limits of mental maturity about fourteen or fifteen years when both sexes are considered together. Later it was believed that mental maturity was concomitant with physiological maturity as determined by anthropometric measurements, which set the limits about the age of eighteen years. The current intelligence tests have been devised primarily for pupils who range in age from kindergarten through high school, and little is known of the intellectual ability

of the adult population. Studies which deal with adult learning and some curves of problem-solving ability would tend to cast doubt upon the view that the limits of mental growth are reached by the age of sixteen or eighteen years. It is probable that mental capacity may continue to develop after physical traits have reached full maturation.

Much of our thinking about the relation of physical and mental traits has been based upon the growth curve, which shows that physical and mental traits tend to develop in the same manner. As has already been noted, the relation between physical and mental traits is positive, but is not close enough to predict ability in mental traits on the basis of a given amount of ability in physical traits. Although as yet there appear to be no tests which will adequately measure the physical and mental growth process, those available show that both physical and mental traits increase with chronological age.

B. Physical Defects

The term *physical defect* has been loosely used to include abnormalities ranging from defects of eye and ear to goiter and speech. Any relationship between physical and mental ability would be noticed in those individuals who suffer from physical defects.

1. The Prevalence of Physical Defects.—Some investigators estimate that 50 per cent of school children are suffering from defects, while others would place the figure as high as 75 per cent. One of the early investigations was by Ayres,[1] who, from a study of 3,304 children in New York in 1908, showed that 75 per cent of the dull, 73 per cent of the normal and 68 per cent of the bright children were defective. His data further showed that among the dull children there were 1.65 defects per child as compared with 1.3 for normal, and 1.07 for bright children. In a later study Gulick[2] and Ayres, from an

[1] Ayres, L. P., *Laggards in Our Schools*, New York, Russell Sage Foundation, 1908.

[2] Gulick, L. H., and L. P. Ayres, *Medical Inspection of Schools*, New York, Suvey Associates, Inc., 1913.

examination of approximately 100,000 children, found from 66 to 72 per cent physically defective. Mallory[1] reports 64 per cent of children defective in a city of Tennessee in 1922. For the year 1923–1924, 62 per cent of the children were reported with physical defects in cities of New York State; in villages, 54.4 per cent; and in rural communities, as high as 62.5 per cent. Investigations conducted in Philadelphia, Chicago and New York from 1919 to 1922 show defects as indicated in Table 38.

TABLE 38.—PREVALENCE OF PHYSICAL DEFECTS
(After Newmayer, 1924)*

	Philadelphia	Chicago	New York
Number of children examined	125,577	510,089	294,754
Number of children in need of medical attention	82,113	316,898	203,184
Percentage of defectives among children	65	60	70

* NEWMAYER, S. W., *Medical and Sanitary Inspection of Schools*, Philadelphia, Lea and Febiger, 1924.

The discrepancy in estimates is due in some degree to differences in opinions as to what constitutes a defect and to what degree it is present in order to be so classified. The discrepancy is also due to differences in measurement, detection and recognition of defects and to the efficiency of the medical inspection program sponsored by school systems. Climatic and other environmental conditions peculiar to sections of the country are factors which partially account for the differences shown. Considering the findings in general, it may be assumed that about 65 per cent of the American school children have some kind of physical defects.

2. The Distribution of Physical Defects.—The distribution of defects is influenced by climatic and environmental conditions. Cases of goiter are of common occurrence in the mountain and central areas of the country while they are of rare occurrence in the coastal regions. Similarly there are other

[1] MALLORY, J. N., A study of the relation of some physical defects to achievement in the elementary school, *Peabody Coll. Teach. Contrib. Educ.*, 1922, No. 9.

defects and diseases which occur most frequently in certain localities because of conditions peculiar to them. Distribution is also affected by racial and social groups. Sections representing settlement and immigrant groups may be expected to show a much higher percentage of defects than others.

The reports which follow represent surveys made in several sections of the country under different environmental and climatic conditions; they should give an accurate picture of the general situation in this country. The data of Table 39 are based upon the records of the cities of Philadelphia, New York and Chicago for the years 1919–1922.

Table 39 shows a wide variation of percentages found by investigators in the several cities. The differences are partially due to a lack of agreement as to what constitutes defects and to different techniques employed in their detection.

TABLE 39.—THE DISTRIBUTION OF PHYSICAL DEFECTS
(After Westerberger, 1927)*

	Philadelphia	Chicago	New York
Number examined	230,528	125,577	294,754
Defects found, per cent			
Eye and vision	10	12	14
Naso-pharynx	18	37	14
Hypertrophied tonsils	39	61	55
Adenoids	30	30	
Miscellaneous	41	9	45
Ear and hearing	2	1	1
Teeth	52	31	26
Skin	7	1	
Orthopedic	3	1	1
Nervous diseases	1	1	1
Cardiac	1	1	2
Nutrition	6	12	19
Goiter	1	3	

* WESTERBERGER, E. J., A study of the influence of physical defects on intelligence and achievement, *Cath. Univ. of America, Educ. Res. Bull.*, 1927, 2.

The preceding tables have shown the prevalence of physical defects among school children and the distribution of specific defects existing among them. Objective studies have been

made to determine the relation between physical defects and scholastic achievement, intelligence, school progress and promotion. If a causal relation is found between physical defects, intelligence and school progress, there is need for the school to detect, correct and prevent defects in children.

3. **Physical Defects and Intelligence.**—Investigators generally believe that the intelligence quotient is relatively constant and hereditary and that little change can be effected through environmental influences to improve the quality of innate ability. However, the current intelligence tests are measures of both innate and acquired ability and it is difficult to separate the influences of heredity and environment. Curiously enough some of those who think that there is little that can be accomplished to improve the quality of general intelligence believe that accident, disease and physical defects tend to lower it. If such environmental factors are influential in decreasing intelligence, it is equally logical to assume that improved nutrition, sanitation, correction of physical defects and medical care would tend to improve intelligence. The early investigations dealt mainly with two extreme groups of individuals—those representing the lower end of the intellectual scale and those of the upper end. It was shown that dull and feeble-minded children possessed many physical abnormalities, while bright children were superior both in physical traits and general health. By studying the physical condition of children of the extremes of intelligence it was believed that the bearing of physical traits on mental ability could be determined.

Few studies have analyzed the influences of physical defects on intelligence in a scientific manner and only a small number of defects has been considered. The general procedure has been to measure the changes in intelligence following the removal of defects. It is apparent that the validity of this method depends upon the length of time elapsing after the removal of defects, as some time would be needed by those operated upon for physical recuperation and mental adjustment. Mental changes immediately following the removal of physical defects are slight and for the most part negligible.

Rogers[1] compared the intelligence levels of two groups of children selected from a public school in New York. One group had diseased tonsils and adenoids and the other group was free from them. Her study indicates that children operated upon for adenoids and defective tonsils show no difference in average intelligence quotient 6 months or even 12 months after operation when compared with an equal number of children of the same chronological age not possessing these defects. Rogers further compared the operated with the nonoperated group on the basis of certain physical measures, such as height and weight. Six months after operation for adenoids and defective tonsils there was found a slight but unreliable gain in weight, but after twelve months the increase was marked. Gain in height as a result of operation was very slight. Similar studies have been made by Terman,[2] Cornell[3] and Lowe[4] with comparisons based upon figures obtained months after operation through an entire year; the conclusions have in general agreed with those of Rogers.

Unfortunately the studies have been limited to only a few types of defects and most of them have been confined to adenoids and tonsils. It is possible that other defects would more directly affect intelligence than those considered here. Since the intelligence quotient is relatively constant, any significant change in intelligence could not be expected. However, the removal of diseased adenoids and tonsils results in better health, less fatigue and more resistance to disease, thus contributing to the child's bodily vigor and stamina. The child's intelligence is freed to function without impediments which impair personality and efficiency.

4. Physical Defects and School Progress.—Physical defects, if they are impediments to mental growth, should be in evidence when the schoolroom situation is confronted. It is

[1] Rogers, Margaret C., Adenoids and diseased tonsils: their effect on general intelligence, *Arch. Psychol.*, 1921, 7, No. 50.

[2] Terman, L. M., *Intelligence of School Children*, New York, Houghton Mifflin, 1917.

[3] Cornell, W. S., The effects of the removal of adenoids, *School Hygiene*, 1907.

[4] Lowe, Gladys M., Mental changes after removing tonsils and adenoids, *Psychol. Clin.*, 1923–1924, 15, 92–100.

equally obvious that some defects would have more influence on school achievement than others. The early studies of Ayres, Cornell and Taussig were emphatic in their conclusions that physical defects constitute a cause of school retardation. Teachers' marks were often used to estimate achievement and scholarship, and the measurements for physical defects were not always made by specialists. In brief the early studies were not strictly objective in their approach. Recent findings are characterized by greater accuracy in measurement and better control of extraneous factors, but these studies are limited in number.

A comprehensive objective study was made by Mallory,[1] who investigated the relationship between several physical defects and achievement in different school subjects. For the measurement of achievement and intelligence standardized tests were employed and the physical examinations were conducted by a trained nurse. The degree of association between physical defects and achievement was determined by Pearson's Association formula. As a result of the application of this formula Mallory obtained a coefficient of 0.21 ± 0.03, which means that a pupil without physical defects is more likely to make a high score on an achievement test. In addition to showing the relation between physical defects and achievement in general, he determined the degree of association between specific types of defects and achievement scores. In order to show the relationship between each type of defect and each school subject, coefficients of association were obtained as indicated in Table 40.

Mallory interprets the data of Table 40 as follows:

> On the whole, a positive association exists between defects and positive abilities. The one noticeable exception is a negative association of sound vision with five of the eight subjects mentioned. The subjects least affected by physical defects are Trabue Completion and Writing. Writing is more or less mechanical and it was observed that there was considerable uniformity in the answers to the simple tests in composition, while comparatively few tried the more difficult ones except in the higher grades. It appears from the table that the five major defects, in order of their

[1] MALLORY, *op. cit.*

positive association with low scores, or stated in the opposite way, in order of their negative association with high scores, are nasal defects, hearing, teeth, tonsils and vision.

TABLE 40.—SUMMARY OF COEFFICIENTS OF ASSOCIATION BETWEEN EACH PHYSICAL DEFECT AND THE VARIOUS SUBJECTS
(After Mallory, 1922)

Subjects	Tonsils	Eye vision	Nasal defects	Teeth	Hearing
Trabue completion	0 096	−0.045	0.026	0.029	0 090
Reading rate	0 044	−0 076	0.244	0.157	0 123
Reading comprehension	−0 071	0.008	0.043	0.124	−0.011
Spelling	0 080	−0.031	0.227	0.011	0 055
Geography	−0.058	0.114	0.139	0.032	0.148
Writing	−0.004	0.001	0.063	0.074	−0.070
Arithmetic	0.151	−0.005	0.246	−0.016	0 070
Composition	0.068	−0.192	0.049	0.012	−0 033

It is conceivable that the relation between physical defects and achievement might be influenced by other factors such as attendance, retardation and intelligence. To determine the association between defects and achievement when these factors were eliminated, Mallory used the method of partial correlation and found the results given in Table 41.

TABLE 41.—ORIGINAL AND DERIVED CORRELATION COEFFICIENTS WITH PHYSICAL DEFECTS AND ACHIEVEMENT
(After Mallory, 1922)

	Original Q.	Q. with influence of intelligence eliminated	Q. with influence of retardation eliminated
Tonsils	0.138	0.122	0.110
Vision	0.029	0.010	0.024
Nasal obstruction	0.799	0.811	0.814
Teeth	0.302	0.294	0.289
Hearing	0.351	0.266	0.262
General defects	0.210	0.175	0.126

The results of these computations indicate that there are not many changes produced in the relation of physical defects and

achievement when intelligence and retardation are held constant. The coefficients are all positive and high enough to be indicative. The closest relationship is found between nasal obstruction and achievement and the lowest association is between vision and achievement. Teeth and hearing defects are of about equal significance as handicaps to achievement. Mallory concluded that physical defects are definitely associated with low scores on achievement tests and that they constitute a cause of low attainment. The defects most closely related to achievement, ranked in the order of their relationship, are: (1) nasal obstruction; (2) defective teeth; (3) defective hearing; (4) defective tonsils; and (5) defective eyes, which includes both defective eyes and defective vision, the latter being only slightly associated with low achievement. Although Mallory's investigation is one of the most comprehensive, it made no attempt to determine the effect of removal of defects upon achievement and intelligence.

McPhail[1] made a study of the scholarship records of 31 children to determine the influence upon scholarship of the removal of adenoids and tonsils. The scholarship records obtained 10 months after operation were compared with those obtained 10 months before. These records showed that one-third of the 31 cases had improved. In the second year the scholarship records of 18 children had improved. Records of 11 children were available for the third year and these cases showed that the scholarship records were an improvement over the period previous to the operation.

The assumption has been generally held that the presence of physical defects is a contributing cause of retardation in mental and educational development. Physical defects are retarding factors in school achievement although the influence is for the most part indirect. Some physical defects do not constitute serious impediments to educational achievement. However, the influence is largely dependent upon the seriousness and number of defects. Improved health resulting from the

[1] McPhail, A. H., Tonsils and adenoids: how removal affects education of the child, *Ped. Sem.*, 1920, **27**, 188–194.

removal and correction of physical abnormalities produces better attention and emotional response, with greater resistance to fatigue in the schoolroom. Indirect influences of physical defects have far-reaching consequences in producing disposition and character, and objective studies do not always show the seriousness or the extent of influence produced by these ailments.

C. Visual, Auditory and Speech Defects

The formation of accurate perceptions is dependent upon the ability to see, hear and verbally report experiences. From the standpoint of the school the eye ranks first, the ear second and speech probably third. Defects in any one of these interfere with efficiency in learning and teaching.

1. Visual Defects.—Indirect effects of eyestrain, such as nervousness, lack of concentration and susceptibility to fatigue, are recognized by every observant teacher. Common refractive defects usually found among school children are hypermetropia, myopia and compound myopic astigmatism. The definitions and commonest symptoms of refractive defects are outlined by Berkowitz[1] as follows:

In cases of hypermetropia (longsight), the condition in which the eyeballs are too short from before backwards, the child can often see distant objects well, but has difficulty in reading, sewing, etc., after using the eyes continually for some time. The type becomes blurred, and the letters run together; the eyeballs ache, and headache is felt, usually over the eyebrows.

These symptoms constitute eye-strain, and are chiefly due to overaction of the ciliary muscle, a small muscle situated inside the eyeball; by its action the shape and position of the lens are altered so as to allow objects at different distances to be focused on the retina at the back of the eye. This power of altering the focus of the eye is called "accommodation."

In high degrees of hypermetropia the child holds the book close to the eye.

In cases of myopia (shortsight), the condition in which the eyeballs are too long from before backwards, the children cannot see the blackboard when seated at the back of the class, or tell the time by the clock when placed at the other side of the room; they hold books near their eyes and

[1] Berkowitz, J. H., The eyesight of school children, *U. S. Bur. Educ. Bull.*, 1919, 65, 1–57.

stoop over their work; after working by artificial light, the eyes become tired.

In cases of astigmatism the eyeball is curved unequally in different directions. Both hypermetropic and myopic astigmatism occur.

With hypermetropic astigmatism, the commoner form, eye-strain is more often associated than with any other abnormality of the shape of the eye.

Children with myopic astigmatism chiefly complain of inability to see distant objects.

The commonest type of defect among children entering school is hypermetropia. Myopia is seldom found among young children, but becomes prominent as the children progress in school. Medical authorities believe that myopic conditions are usually due to strained and unhygienic use of the eyes.

a. The Prevalence and Distribution of Visual Defects.—It is estimated that about 25 per cent of school children have defective vision. The different percentages obtained by various investigators are due not so much to differences peculiar to sections of the country, but to differences in the methods of testing, degree of efficiency and the organization of medical inspection in the various schools. For example, in the New York schools from 1909 to 1915, 10.5 per cent of the children were tested for vision, while in Boston it was found that for the year 1907 there was a maximum of 31.5 per cent tested, and in 1916 a minimum of 12.85, the average for 10 years being 18.06 per cent. The percentage in London was 20.2 and a report on 64 areas in England and Wales showed an average of only 10.5 per cent.

Carhart[1] has reported some interesting data on the frequency of refractive defects in a group of 1,000 children whose ages range from five to eighteen years. These children were from village schools and represented for the most part children from American-born parents of the better class; they are, therefore, representative of the native white element, while the figures given from the previous cities and countries represent many races and social classes. Table 42 presents the types of

[1] Carhart, W. M., Retardation in school from refractive errors, *Amer. School Hygiene Ass'n Proceedings*, New York, 1917.

refractive errors found among the 1,000 children and the distribution of these same children according to the age groups into which they were classified.

The facts indicated by Table 42 show that there is a marked decrease of hypermetropia as children become older. It occurs

TABLE 42

1. Percentages of refractive errors in 1,000 school children, ages 5 to 18 years

	Percentage
Emmetropia	13.9
Hypermetropia	36.2
Compound hypermetropic astigmatism	44.0
Myopia	1 4
Compound myopic astigmatism	3.5
Mixed astigmatism	1.0

2. Percentages by ages of the same 1,000 children

	5 to 8 years	9 to 12 years	13 to 18 years
Emmetropia	10.00	16.43	14.33
Hypermetropia	53.48	37.27	22.87
Compound hypermetropic astigmatism	33.48	40.05	58.55
Myopia	0.87	1.85	1.17
Compound myopic astigmatism	1.74	3.01	5.26
Mixed astigmatism	0.43	1.39	0.88

among 53.48 per cent of the children at five to eight years of age and among only 22.87 per cent at thirteen to eighteen years. The constant strain incurred in the schoolroom causes irregular yielding of the structure of the eyeball as revealed by the increase of astigmatism, the hypermetropic, mixed and myopic types occurring in about the same degree. Myopia without astigmatism is frequently found in the middle years of school life because of strain, although children with marked myopia, resulting in seriously defective vision, are forced to drop out of school in the grammar grades, making the percentage of myopia among high-school pupils less than in the grammar grades. Emmetropia is due to the fact that the eyeball lengthens as

the child becomes older and the highest percentages are found in the middle grades. The percentages for the various age groups indicate that refractive errors when present are influenced by the strain of schoolwork and even though unnoted may in some degree be affected by the work of the school.

b. Visual Defects and School Progress.—The investigations reviewed in a previous section showed in general that children suffering from physical defects are more retarded in school than children who are free from such defects. It was also indicated that visual defects do not exert as serious a handicap as some of the others. Defective vision does not appear to be greater in extent than other defects in retarded children, but on the contrary in some groups a larger percentage of defective vision exists in the bright than in the dull children. The problem has been studied to discover the number of defects found among bright children as compared with dull, and among nonexempt children as compared with those who are exempt from examinations. In these studies "bright" and "dull" are determined by teachers' estimates and school marks, and usually show that there is a larger percentage of defective vision among dull and retarded children than among bright pupils. However, the results are not convincing, and much more study is needed to determine the bearing of visual defects on school progress. Defective vision is progressive and is found more frequently among older children in the schools. Influences unfavorable to normal vision are found both within the school and within the home. Poor lighting and studying conditions may be serious factors in the home; in the school unfavorable conditions include natural and artificial light, interior colors, desks and seats, blackboards, books and other factors. These influences should be considered in the school hygiene program.

2. Auditory Defects.—The symptoms of impaired hearing are not readily recognized by teachers. Pupils suffering from defective hearing are sometimes rated as stupid because of their apparent lack of interest and general alertness. Such pupils are easily fatigued and are under emotional strain while in the schoolroom. Children with slightly impaired hearing seldom

realize that they are unlike their schoolmates. That these children perform their schoolwork under serious handicaps is evident to all.

a. The Prevalence of Auditory Defects.—Diseases of the ear are common but most investigators do not clearly differentiate between impaired hearing and such diseases. This condition alone may partially account for the wide variation in the frequencies with which auditory defects are found in various sections of the country. In order to show the variation in the findings of investigators, Table 43 has been prepared, which shows the prevalence of ear and hearing defects in several cities and states. From these and other data it may safely be estimated that approximately 5 per cent of school children are suffering from either ear or hearing defects of a slight or marked character.

TABLE 43.—PREVALENCE OF EAR AND HEARING DEFECTS AMONG SCHOOL CHILDREN

	Pupils examined	Per cent
Massachusetts:[1]		
1907	432,464	6.3
1908	437,435	5.2
1909	441,465	4.6
1910	454,058	3.8
Maine—1911[2]	87,954	4.6
Philadelphia—1919–1922[2]	230,528	0.02
Chicago—1919–1922[2]	125,577	0.01
New York—1919–1922[3]	294,754	0.01
New York—1923–1924[3]	600,000	1.2

[1] GULICK and AYRES, *op. cit.*
[2] *Ibid.*
[3] WESTERBERGER, *op. cit.*

b. Causes and Treatment of Defective Hearing.—Defective hearing is closely associated with some of the other defects already discussed, and it is, therefore, difficult to determine the amount of handicap a child suffers from poor hearing. One

of the common causes of impaired hearing is the presence of enlarged or diseased adenoids and tonsils; treatment of defective hearing may, therefore, be indirect by removing adenoids and tonsils. Enlarged tonsils prevent free passage of air into the Eustachian canal and impede the conduction of sound. Another cause of impaired hearing is the inflammation of the middle ear caused by the formation of an abscess, a frequent result of scarlet fever and measles. Defects of hearing and diseases of the ear require a careful inspection of nose and throat for causative factors. Systematic examination of the ears and expert treatment of abnormalities when the child enters school would decrease the frequency and seriousness of deafness. Children with ear defects recommended for treatment in Philadelphia in 1922 are presented in Table 44.

TABLE 44.—EAR DEFECTS RECOMMENDED FOR TREATMENT (Philadelphia, 1922)*

Defective	1,045
Otitis media (chronic supurating)	916
Otitis media (acute)	661
Impacted cerumen	64
Miscellaneous	13
Total	2,699

* NEWMAYER, S. W., Medical and Sanitary Inspection of Schools, Philadelphia, Lea and Febiger, 1924.

c. Auditory Defects and School Progress.—The influence of poor hearing upon achievement and school progress has been indicated by many investigators, but as in the case of visual defects the findings are not conclusive. However, it is well known that the efficiency of instruction is lowered by the presence of children whose hearing is difficult. Some children because of this deficiency make no effort to understand the instruction of the school; others exert much energy to hear instruction, but do so under emotional strain and excessive fatigue. Achievement of those who have defective hearing is usually lower than those free from hearing defects, but it cannot be said that impaired hearing is always or even usually associated with low mental and scholastic standing.

Madden[1] found that the difference between a group of hard-of-hearing children and a control group with which it was compared was slightly in favor of the control group. Those with defective hearing were superior in word meaning, spelling and arithmetical computation as measured by the Stanford Achievement Test, but in no case was the difference statistically significant. He also found little difference in intelligence between the defective children and the normal group. The method of conducting regular classroom instruction for children with normal hearing places those with auditory defects under a disadvantage. Children who have a hearing distance of three feet and four inches for whispered language can follow with effort the instruction in the school,[2] but those whose hearing is less than this usually need to be placed in special classes.

It is frequently possible for teachers to detect children who have difficulty in hearing. Some children learn lip-reading, and the child who observes the teacher closely while she is talking may be suspected of deafness. Deaf children usually speak in a low voice because hearing by tone is increased by chronic catarrh or abscess, which causes the child's voice to sound loud to himself. On the other hand a child with inner-ear trouble has diminished bone abduction and his voice sounds low to himself. Another symptom is observed when a child, with possibly a strained or puzzled expression on his face, turns his good ear toward the teacher. Earache often indicates the beginning of a middle-ear abscess. In all of these cases children should be referred for examination to a physician.

3. Speech Defects.—Normal speech is an important factor in the child's happiness as well as in his school progress. Speech defects are of several types ranging from those which are simple to marked stuttering and stammering. The following definitions listed by Root[3] cover the major types of speech defects:

[1] MADDEN, RICHARD, The school status of the hard-of-hearing child, *Teach. Coll. Rec.*, 1932, **34**, 59–60.

[2] SONNENSCHEIN, ROBERT, Signs and symptoms of common nose, throat and ear conditions including defective hearing, *Elem. School J.*, 1927–1928, **28**, 436–442.

[3] ROOT, A. R., A survey of speech defectives in the public elementary schools of South Dakota, *Elem. School J.*, 1925–1926, **26**, 531–541.

1. *Stuttering and stammering.* Where phonation is continuous or interrupted by spasms of the organs of respiration, or articulation.

2. *Lisping and lolling.* Where the pupils use the wrong sound for *s*, *z*, *th*, *l*, and *r*. Foreign accents not included.

3. *Thick speech.* Where children have poorly developed tongues caused often by rickets or lack of thyroid secretion, resulting in cretinism, or are unable to make fine coordinations necessary for correct speech.

4. *Aggramatism.* When children persist in not speaking grammatically after, say, the age of four years. This type may be able occasionally to repeat simple sentences.—Example of form of defect: "Doll kiss, sleep go."

5. *Mutism.* A defect where the child because of mental conflicts refuses to speak to strangers or is unable to speak with them, but is able to talk normally to certain persons, usually the members of his family.

a. The Prevalence and Distribution of Speech Defects.—Many difficulties are encountered in attempting to determine the prevalence of speech defects. Most investigators have attempted to determine the frequency of such defects by the questionnaire method and from teachers who are untrained in the detection of speech defects.

Root, using the questionnaire method, made a study of 14,172 pupils in the public schools in South Dakota and found defects as shown in Table 45. It may be observed that the

TABLE 45.—PERCENTAGE OF PUPILS WITH SPEECH DEFECTS IN EACH GRADE OF THE PUBLIC ELEMENTARY SCHOOLS OF SOUTH DAKOTA
(After Root, 1926)

Grade	Per cent of pupils with speech defects
1	9.3
2	7.5
3	5.6
4	6.4
5	6.0
6	4.9
7	4.1
8	4.0
Mean	6.3

prevalence of speech defects does not remain the same for all grades of the elementary school, the tendency being for these

defects to decrease as the higher grades are reached. Root believes that the number of stuttering and stammering children increased in grades 4 and 5 and decreased in grades 7 and 8. This condition is probably accounted for by increased speech consciousness, the decrease in grades 7 and 8 being due to the fact that the discouraged children dropped out of school. The figures presented by Root are typical of those found by other investigators.

b. Causes and Treatment of Speech Defects.—Speech defects may be traced to both hereditary and environmental causes. There may be physical disorders and malformations which are difficult or impossible to correct. Among some of the environmental causes of speech disorders are (1) parents encouraging baby talk; (2) children imitating parents with defects; (3) home conditions which promote timidity, jealousy, shyness, a lack of confidence or extreme nervous tension; (4) speech disorders caused by nervousness or shock in the home.[1]

The difference between stammering and stuttering is that stuttering is psychological in character, being under the control of the will, while stammering is not. When stuttering is allowed to go uncorrected, it often develops into stammering. Stammering is due to a conflict between normal speech and a conscious though misdirected effort. The habit stage of stammering is often produced by shock or excessive fatigue. When the individual consciously tries to correct his inaccurate movements which accompany stammering, the effort produces muscular tension which impresses itself on the individual's memory, and when he again makes the sounds there are excessive muscular movements. If the individual could only forget that he had stuttered, he would probably never do so again.

It is easy for the stammerer to say what his auditor already knows. The stammerer will stammer when speech is uppermost in his mind and there is conscious effort to talk. Some specialists consider stammering as a psychosis based upon a

[1] LIMA, MARGARET, Speech defects in children, *Ment. Hygiene*, 1927, 11, 795-803.

delusion that there exists an impediment to the free use of speech. Tompkins[1] claims that it is not a delusion but a reality, as evidenced by the fact that the child will not notice the habit he has formed until ridicule brings it to notice so forcibly that there is a conscious effort to overcome it. There are also cases on record in which stammering was begun as aphasia due to loss of memory. When the individual regains his memory and notices disability in his speech, he makes a conscious effort to talk, and although he recovers from aphasia the stammering remains.

The stammerer finds no difficulty in talking when in solitude[2] or while singing. When he is in solitude he is his own auditor, and since he knows his thoughts there is no need of speaking and there is no effort made if they are not spoken. Time beating to cure stammering seems to show that rhythm is helpful; the greater part of the advantage, however, seems to be in the distraction it affords. The gradual start in singing tends to prevent convulsive actions which are characteristic of stammering. The continuity of sound in singing also decreases stammering because the start is the most difficult for the stammerer and continuity reduces the number of starts. The accented vowels in singing are simpler to produce than the articulated words of speech. Gradual start, continuity of sound and accented vowels are the most important factors which eliminate stammering in singing.

Some speech specialists believe that cure of stammering is as low as 2 per cent while others would place the figure as high as 10 per cent. Special training is usually not advocated because it only serves to bring the stammerer's attention to his defect. Self-confidence will do most to cure stammering. In the schoolroom the pupil should be allowed to do as much writing as possible as a substitute for talking. Contact with friends and those who are congenial lessens embarrassment and thus contributes toward cure. The good speech teacher, by stressing

[1] TOMPKINS, ERNEST, The pedagogue and the stammering child, *Ped. Sem.*, 1916, 23, 128–129, 153–174.

[2] *Ibid.*

relaxation, self-confidence and correct vocalization, may do much to overcome nervous and emotional disorder. Thoughtful parents can also help to increase confidence in the stammering and stuttering child.

c. Speech Defects and School Progress.—Speech defectives are not necessarily mentally or educationally retarded, but the presence of speech defects often causes emotional and nervous reactions which are impediments to mental and scholastic growth. Westergard, in an investigation of 34,000 school children with speech defects in Germany, found that the majority of them were not promoted regularly, and that after the ninth year in school practically all of them were eliminated. Conradi,[1] in an analysis of 87,440 school children in six American cities, found from age-grade records of elementary-school children that the majority of speech defectives were normal for their age. Root[2] found that the amount of retardation varies with the type of defect. He indicated that as a rule stutterers and stammerers are better able to make progress through school than other types of speech defectives. Defectives with indistinct speech are retarded the greatest amount, those with thick speech, mutism, lisping and lolling, nasality and stuttering following in the order named. The greatest hindrance is found in shyness, embarrassment and self-consciousness. The pupil is further handicapped by the feeling of inferiority which is produced by his condition. As in the case of the other defects, the impediment is dependent upon the nature and seriousness with which defective speech is present. Sympathy and understanding are needed on the part of both teachers and parents.

D. Summary

Both the positive and negative aspects of the relation between physical and mental ability have been considered. On the one hand we have shown the relationship between physi-

[1] Conradi, Edward, Speech defects and intellectual progress, *J. Educ Psychol.*, 1912, **3**, 35–38.

[2] Root, *op. cit.*

cal and mental traits and on the other the relation between physical defects and mental and educational growth.

The various measures of physical growth so far developed are in the main unsatisfactory gauges of physical maturation and do not accurately indicate the individual's mental and educational development. The relation between physical and mental traits is positive though low, which is true whether we take physiological ages, time of sex maturation or the glands as measures of maturity. These measures taken singly do not afford an accurate index of either physiological or mental growth, but if used compositely should prove of considerable value as a basis for predicting mental and educational growth. Physical defects exert an indirect influence upon mental and educational growth by producing lessened resistance to fatigue, decrease in bodily vigor and the lowering of general efficiency. The degree of influence manifested by defects is dependent upon the number, character and seriousness of the defects present in the child. Removing and treating defects enable a freer expression of the child's personality.

The importance of normal sense organs cannot be overemphasized. In order that the child may form accurate perceptions, he must be able to see, hear and verbally report his experiences. Visual defects show larger percentages as children grow older. Although they constitute a chief impediment to efficiency of instruction, they are not necessarily associated with low intelligence and achievement. Auditory defects conform to the same principle. The child suffering from speech defects is usually under emotional strain and embarrassment and finds school life an unpleasant undertaking. The function of the school is to detect defects, to cooperate with specialists in their correctioh and to provide surroundings which will help to prevent their occurrence and development.

CHAPTER XIX

PERSONALITY AND MENTAL HYGIENE

The individual's traits, whether intellectual, social or emotional, are directly affected by glands, the nervous system and other physical features which are transmitted from one generation to another. Early experiences before the child enters school also influence his later reactions. Both heredity and environment have had their part in shaping individual differences before the child's formal education begins. However, the majority of problems brought to the attention of psychologists indicate that the schools do not adequately recognize individual differences in pupils.

Children between the ages of six and sixteen are required to attend school and to follow for the most part a uniform program. Under such a regime of standardization and uniformity in methods and organization even the student of strong personal characteristics may fail to adjust himself to the life of the school. If he is of superior intelligence and not provided an outlet for native abilities and interests, habits of inefficiency may result. If he is of inferior intelligence, he may feel crushed through failure of accomplishment. If he lacks drive, initiative or other temperamental qualities, he may suffer from the competitive life of the group. In any case a student who adjusts himself to a standardized program must at times feel that his individuality is being sacrificed. To facilitate the school's organization and methods individual differences have been frequently overlooked; as a result children experience frustration, resistance and suspicion which are not always outwardly expressed.

The school, in order adequately to recognize individual differences, should consider the traits that combine to make personality. The term *personality* is psychologically used

to include the sum total of the individual's traits, especially as viewed from social angles, while mental hygiene implies balancing and controlling such traits. Psychologists have analyzed personality into various elements, and through such analysis it has been possible to classify general and intangible traits into their subordinate elements so that they may be more definitely studied. Personality is described in terms of physical, mental, social and emotional reactions, the sum total of which are needed to characterize the individual's behavior. While analysis is essential for scientific study, the impression should not be left that the individual can be understood by viewing fragmentary phases of the whole personality.

In stressing intellectual traits the schools have overlooked other characteristics which form a significant part of personality and are equally important for success. Since mental hygiene implies the balancing of various traits and functions, the importance of considering the whole personality cannot be overemphasized. Adolph Meyer says: "What we call mental health is the hanging together of all the various functions and activities with a sound flow of constructive and reactive imagination and fantasy life—a fantasy able to reach and use reality. Health has to show in the digestion of the past and in the anticipation of present experiences." The individual does not react according to separate and specific traits but as a total personality. The program of mental hygiene aims to develop wholesome and balanced personalities and to correct undesirable traits. It attempts not only to discover the traits that constitute personality, but to assist the individual in developing and disciplining his traits to the best interests of himself and society.

A. Behavior Traits in Children

Statistics show that in the hospitals of the United States there are more persons mentally sick than physically sick. It is estimated that one out of 21 persons in the general population has been or will have been at some time in a psychopathic institution unless care has been taken to prevent mental

illness.[1] Based upon 1930 figures this means that approximately 1,000,000 of the 24,000,000 now enrolled in the schools are likely to manifest mental maladjustment unless protective measures are taken to prevent this condition. These figures taken at their face value indicate a deplorable condition, but in their real meaning imply that individuals are likely to manifest undesirable traits at some time, which if not corrected may later lead to serious maladjustment. The facts presented raise the question as to what constitutes normal behavior. How many good traits are necessary for a wholesome and balanced personality? How many undesirable traits may an individual possess and remain within the range of normality? Definite answers to such questions cannot be given until norms developed on the basis of large numbers of cases have been provided. As in every new field, mental hygiene has dealt with those who deviate markedly from the average and most of our knowledge has been derived from the abnormal individual. The psychiatrist is mainly interested in the abnormal individual while the school is concerned chiefly with the relatively normal child.

The terms *desirable traits* and *undesirable traits* can be used only in a relative sense. What could be a very good trait may without proper direction become undesirable. A certain amount of a trait may be desirable, while more of that trait may be undesirable. For example, aggressiveness is a trait necessary for success in any work, and yet if it is developed to the extent that the individual is offensive to his associates it is undesirable. Some introversion is necessary for scholarship and productive thinking, but if the trait is developed to the degree that it causes one to become moody and introspective it is undesirable. An individual may demonstrate normal behavior in one situation and abnormal behavior in another. It is probable that the normal individual possesses many traits common to the abnormal person, but there is a balance of relationship among his various traits. Statistically interpreted,

[1] McCartney, James L., Mental hygiene in a public health program, *Amer. J. Public Health*, 1930, 20, 943.

the normal individual is probably one who possesses traits similar to those of representative groups of the population.

Behavior traits in children have been rated by teachers, parents and mental hygienists. Score cards, check lists, questionnaires and other types of measuring instruments have been used. Blatz and Bott,[1] rather than make a list of traits to be rated by parents and teachers, approached the problem by an inductive method which consisted in having teachers in a large public-school system list as they occurred the types of behavior which they considered misdemeanors. The misdemeanors listed by those teachers were then classified from year to year and modified as new types of misconduct were reported. The results of three years of such work made it possible to standardize a classified list of misdemeanors as shown in Table 46. The check list thus furnished a means of systematically studying the behavior of children. It was found that the number of misdemeanors was not closely related to age, although the largest number appeared between the ages of seven and nine. Intelligence quotients were inversely related to the number of misdemeanors of boys, but not of girls. There appeared to be no significant difference between the number of misdemeanors and the sex of the pupils.

TABLE 46.—A CLASSIFIED LIST OF BEHAVIOR TRAITS OF CHILDREN
(After Blatz and Bott, 1927)

1. Disobedience.
   a. Petty—slow to respond—reluctant attitude—breaking minor rules of classroom.
   b. Gross-deliberate refusal to obey commands—resistance to corporal punishment.
   c. Writing notes.
   d. Doing work other than prescribed—reading story books—doing homework during lesson.
   e. Unreliability—general non-compliant attitude.
   f. Forgetting notes and books.
   g. Eating candy or fruit or chewing gum.
2. Disorder.
   a. Disorder in line.
   b. Scuffling.

[1] BLATZ, W. E., and E. A. BOTT, Studies in mental hygiene of children, *Ped. Sem.*, 1927, 34, 553–582.

TABLE 46.—A CLASSIFIED LIST OF BEHAVIOR TRAITS OF CHILDREN.—(*Continued*)

3. Dishonesty.
   a. Stealing (state facts as accurately as possible).
   b. Deceitfulness—tampering with notes, reports, etc.—attempts to deceive or mislead—altering exercises—doing "mental" work on paper.
   c. Lying (state facts as accurately as possible).
   d. Copying.
4. Lack of application.
   a. Restlessness—talking, fidgeting, asking to leave room too frequently without cause.
   b. Inattention.
   c. Carelessness—slovenliness in work, homework, etc.
   d. Laziness—neglect of homework.
   e. Daydreaming.
   f. Bad posture—slumping in seat.
5. Personal uncleanliness.
   a. Dirty hands, face, clothes, boots, vermin.
   b. Dirty belongings, books, exercises.
6. Indecencies.
   a. Profanity.
   b. Obscenities—language, poetry, pictures.
   c. Familiarity with opposite sex.
   d. Sex misconduct.
7. Emotional.
   a. Showing off to fellow students (state circumstances).
   b. Bullying, teasing.
   c. Impertinence.
   d. Sulkiness.
   e. Temper outbreaks.
   f. Exuberance—laughing, giggling, whistling.
   g. Excessive timidity—cries easily—very shy—easily embarrassed.
   h. Fighting.
8. Irregularity.
   a. Tardiness—including late for line.
   b. Truancy—due to parents' neglect.
   c. Truancy—without parents' knowledge.
9. Damage to property and persons.
   a. School property.
   b. Personal belongings or wearing apparel of others.
   c. Injury to other persons (state circumstances).
10. Strappings.
    State time of day—number of straps—provocation.
11. Unclassified.

It should be noted, however, that there is a marked divergence between the points of view of mental hygienists and those of parents and teachers as to the seriousness of behavior

traits. Laws[1] found that "parents tend to rate themselves in relation to their children and their practices concerning them somewhat lower than observers rate them." Mothers tended to rate themselves more severely than observers rate them on such traits. In opposition to this tendency toward self-depreciation Laws also found that parents tended to rate the behavior of their children higher than others rate it, except in cases where the trait of the child had been a source of continued irritation. These and other similar facts are frequently pointed out by mental hygienists and child specialists. Much work of the child-guidance clinic should be devoted to a study of home and parental influences in addition to the child himself. The emotional attitudes of parents must be known before the emotional reactions of the child can be understood.

Wickman[2] compared the ratings of 511 teachers and 30 mental hygienists as to the relative seriousness of behavior traits in school children. He found that the traits considered undesirable by mental hygienists were virtually reversed by teachers. Teachers tended to consider as undesirable those traits which in some way interfered with learning and scholarship. Characteristics which tended to interfere with the teacher's program were rated as undesirable. Mental hygienists, on the contrary, while recognizing the undesirability of such traits, tended to stress as undesirable those which concerned the individual in reacting to a social situation. The following diagram by Wickman indicates the teachers' reactions as to the seriousness of several types of behavior problems; the symbol of inequality shows the weighting of the various groups of traits.

Immoralities		Violations of		Extravagant,		Withdrawing,
Dishonesties		orderliness in		aggressive		recessive
Transgressions	>	classroom	>	personality	>	personality
against		Lack of		and behavior		and behavior
authority		application to		traits		traits
		schoolwork				

[1] LAWS, GERTRUDE, Parent-child relationships: a study of the attitudes and practices of parents concerning social adjustment of children, *Teach. Coll. Contrib. Educ.*, 1927, No. 283.

[2] WICKMAN, E. K., *Children's Behavior and Teachers' Attitudes*, New York, The Commonwealth Fund, Division of Publications, 1928.

The ratings of the mental hygienists are not so marked, but the following diagram indicates the trend of their reactions:

Withdrawing recessive personality and behavior traits	>	Dishonesties Cruelty Temper tantrums Truancy	>	Immoralities Violations of schoolwork requirements Extravagant behavior traits	>	Transgressions against authority Violations of orderliness in class

The teachers rated immoralities and violations of orderliness in the classroom and lack of application to schoolwork as more serious than recessive traits and extravagant behavior. The mental hygienists virtually reversed the importance of these ratings by ranking the recessive traits first, followed by extravagant behavior, temper tantrums, cruelty, immoralities and transgressions against authority. The indications are that teachers react to undesirable behavior of the child rather than to the child, himself, who is attempting to solve difficulties of social adjustment. These difficulties are met by evasions which take the form of withdrawal, recessive characteristics or attack, such as temper tantrums or defiance to authorities. The mental hygienist realizes the significance of both types of behavior while the teacher judges the seriousness of behavior problems by the extent to which they are an attack upon the teacher and his professional work. Laycock[1] repeated this study in Canada and found similar results.

Stogdill[2] found that parents tend to place greater emphasis upon moral taboos, parental authority, adherence to group standards and customs than mental hygienists. Parents did not appear to realize the effect that such emphasis may have upon the child's emotional and mental adjustments to life. The mental hygienists, because of their broad view of the field of mental hygiene and their study of large numbers of

[1] Laycock, S. R., Teachers' reactions to maladjustment of school children, *Brit. J. Educ. Psychol.*, 1934, 4, 11–29.

[2] Stogdill, Ralph M., Parental attitudes and mental hygiene standards, *Ment. Hygiene*, 1931, 15, 813–827.

individuals in their relationship to many situations, represent a sounder viewpoint than do teachers or parents.

Some of the reeducative measures suggested by Wickman on the basis of his study are:[1]

That behavior problems in children are those forms of behavior which are declared undesirable or unwholesome by social and personal attitudes. When considered from an objective point of view behavior disorders arise out of a discrepancy between the child's capacity to behave and the requirements of behavior which are imposed upon him by parents, school teachers, companions, and social organization. The factor of adult attitudes which determines these requirements is an integral part of the production of the behavior problem as well as the child's future behavior adjustment.

That the usual treatment of behavior disorders in children is directed toward the undesirable behavior, which is the symptom of maladjustment, instead of toward the underlying causes that produce the maladjustment.

That teachers be given a more general knowledge of what constitutes normal child behavior. We are in need of a general shift of emphasis from the psychology of learning and intellectual differences in children to the psychology of the social development of children with particular reference to the essential differences between child and adult behavior.

That teachers obtain a dynamic picture of the social and experiential backgrounds of children, as well as of their physical and mental capacities, which operate in the production of healthy and unhealthy modes of child behavior.

That some attention be paid to the emotional and social adjustments of teachers themselves in order that they may be able to withstand the shocks of disobedience, defiance, stealing, lying, truancy, and sex behavior which arise from time to time among children.

Studies of the type reported direct attention to undesirable types of behavior and furnish a means for their evaluation. Many of the traits rated have little significance when they first appear, but may become serious if permitted to develop. Incipient failures in the school should be recognized at the outset so that desires for accomplishment may not be thwarted. The degree of seriousness of an undesirable trait depends upon many factors including (1) the frequency with which it occurs, (2) the age at which it appears, (3) its effect upon others, (4)

[1] WICKMAN, *op. cit.*

the type of situation in which it occurs and (5) physical and mental condition of child at the time.

A trait which occurs infrequently may not be regarded as seriously as one which has become habitual. A trait in a young child may not be considered as serious as the same trait in an older child. If the trait affects the attitudes and dispositions of others, it is more serious than one which interferes primarily with the individual possessing it. Some traits express themselves in unusual situations and not under normal conditions. The trait which expresses itself under comparatively normal situations is more serious than one which occurs only under unusual conditions. Many traits are direct manifestations of the physical and mental condition of the child at the time, while under other conditions they may not be evident. These and other factors should be taken into account in judging the undesirability or seriousness of a trait.

Attention so far in the development of the field of mental hygiene has been directed primarily to discovering and correcting undesirable traits rather than to developing desirable ones. Since the field is comparatively new, it is to be expected that the greater part of the work would be devoted to discovering defects and limitations in personalities. However, emphasis upon detecting undesirable traits has detrimental as well as beneficial effects. Such practice has the effect of causing teachers to search for negative, rather than for positive, qualities in the child. When the importance of taking a composite view of the whole personality is realized, the program of mental hygiene will be more effective than at present.

B. The Case-study Technique[1]

The case-study technique is the most universal approach to the study of personality and mental hygiene. It consists essentially in studying an individual from the standpoint of all his physical, mental, emotional and social traits. The aim is to obtain by means of intensive study a composite picture of the individual in his various relationships. This technique

[1] The writer is indebted to Lovana Stone for aid in writing this section.

has been used primarily to study the abnormal case but may be applied to any individual. The ultimate goal of all case study is to effect improvement in an individual or in his environment. The immediate purpose may vary with the type of case study in question. One type[1] of case study has for its immediate objective the solution of a specific problem of an individual. A second type which may be termed *causal* consists in investigating selected individuals for the purpose of furnishing data to be used as a basis for the solution of the specific problem. Thus applied, this type becomes a means of discovering more generally recurring facts and, with the multiplication of cases, of making generalizations.

Every case study involves: (1) the collection of data; (2) analysis of the data assembled; (3) a synthesis or integration of the parts into an organized whole; (4) interpretation of the past and outlook for the future, sometimes referred to as diagnosis and prognosis; (5) the application of remedial measures; and (6) the development of an adequate case history step by step as the study is being made.

The information required in a case study of a school child may be secured: (1) by direct or indirect observation, in the school, in the home or in other environment; (2) by means of an interview with the child himself, with teachers, parents, truancy officers, physicians, school nurse or others who may have intimate contacts with the child; (3) by the use of rating scales or score cards; (4) by measurement of intelligence and achievement in school subjects; (5) by consulting school records, which should be cumulative; and (6) by consulting the records of social agencies, juvenile courts, physicians or others. In discussing the kinds of data a social case record should contain, Burgess[2] has suggested two approaches in sociology which are equally valid for case study in education. First, there should be a study of the individual's reaction of physical, mental and temperamental traits to environmental stimuli. Secondly,

[1] McCloy, C. H., Methods of research in physical education, *Amer. Phys. Educ. Rev.*, 1929, **34**, 10–16.

[2] Burgess, E. W., Statistics and case studies as methods of sociological research, *Sociol. & Soc. Res.*, 1927, **12**, 117–120.

there should be a study of the case as an integral part of the individual's social setting, which would involve a study of his group relationships, his character as determined by his reactions to different life situations and his personal behavior pattern.

Two outlines, used in other fields and covering the essential points of investigation, are particularly applicable to use in a case study in education and are therefore suggested. The first of these is the form standardized and adopted by the late Walter E. Fernald[1] in his work with mental defectives in the Massachusetts School for Feeble-minded at Waverly. With the possible exception of the field relating to economic efficiency, all of the items are equally applicable to the study of the child in school.

1. Physical examination, made by the physician in charge.
2. Family history. Secured from the family physician, social worker, clergyman and others.
3. Personal and developmental history. Same sources as in family history.
4. History of school progress. Secured from reports of teachers and school records.
5. Examination in schoolwork. This examination is made "on the spot" with pencil and paper.
6. Practical knowledge and general information. A test is given "on the spot" with appropriate questions.
7. Social history and reactions. This information is secured principally from friends and the social worker.
8. Economic efficiency—from employers, friends and social workers.
9. Moral reactions. The same sources as in social history.
10. Mental examination, made by the psychologist in his laboratory.

The "ten standardized fields of inquiry" are given in abbreviated form together with brief statements of the sources of information.

After the child has been studied according to these fields his rating may be estimated by the extent to which each of the fields is designated as positive or negative. In so far as the child has a predominant number of positive ratings, his

[1] FERNALD, W. E., Standardized fields of inquiry for clinical studies and border-line defectives, New York, *Nat. Comm. Ment. Hygiene*, 1922.

chances are favorable for succeeding in the Waverly Institution and becoming eventually a good citizen. Likewise, when the child has a predominant number of negative ratings, his chances of improving under the institution's regime are slight. Children, upon entering the Waverly School, are studied intensively according to these fields, chiefly for the purpose of predicting their probable success.

The method furnishes a means of studying the child both from a "longitudinal" and "cross-sectional" approach. It is "longitudinal" in that in some fields, such as personal, developmental and family history, the child is studied over a period of years extending as far back as birth. It is "cross-sectional" in that in several fields, such as examination of school progress, practical knowledge and general information, it serves to describe present reactions.

Another form recently developed by Patry[1] is designed for teachers. The chart should cause the teacher to ask herself definite questions about each child so that she might do something about their problems. It gives pupils the benefit of periodic check-ups on emotional, social and habit systems. The chart proposed by Patry, by the omission of some items which may not be relevant to a specific problem, or by the inclusion of others, may readily be adapted to the case study in school.

After all relevant data have been assembled in a case study, the material should be analyzed, synthesized and interpreted. There are four steps necessary in the adequate analysis of a case study. First, there should be a careful inventory of specific traits and tendencies. Secondly, there should be a search for symptoms and outward manifestations of these traits and tendencies. Following the search for symptoms comes the definition of items or groups of items and the attachment to each of such significance as may be warranted. Wherever possible, the purely descriptive, subjective data should be converted into objective, quantitative measures. Finally

[1] PATRY, FREDERICK L., A psychobiological balance chart, *Educ. Meth.*, 1933, 12, 400–411.

TABLE 47.—A PSYCHOBIOLOGICAL BALANCE CHART

Name John Brown Age 8 Grade 3 Year 1932

Factors to be evaluated and balanced	Assets	Liabilities	
		Modifiable	To be accepted
I. Complaint Problem	....	1. Unpopular with other children 2. Dislikes school 3. Always in trouble	
II. Facts of family history	1. Mother of even disposition	....	1. Father has spells of temper
III. Facts of development	1. Regular habits of sleeping and eating	1. Temper tantrums 2. Fussiness over food	1. Slow in learning to talk and walk 2. Bed wetting until 5 years old
IV. School facts. . .	1. Average age (8) for his grade (3) 2. No repetition of grades	1. Fights other children 2. Unhappy 3. Difficulty in reading	
V. Home facts......	1. Parents respect law and authority 2. Moderate financial circumstances	1. Parental quarrelling 2. Pupil sleeps with an uncle who awakens him late each night	1. Live in a crowded section of city
VI. Neighborhood facts	1. Good recreational outlets		
VII. Facts of personality traits	1. Respects property rights of others 2. Neat	1. Does not practice self-control 2. Craves attention	1. Ingrowing type of personality
VIII. Habit facts......	1. Good personal hygiene habits	1. Trembles upon oral recitation	
IX. Facts of interests, recreation and companionship	1. Enjoys playing outdoor games with boys of his own age		
X. Facts of physical examination	1. Well-nourished	1. Dental cavities 2. Needs glasses	1. Small stature 2. Many freckles
XI. Facts of mental examination	1. I.Q. 107 2. Prefers concrete work	1. Reading difficulty due to lack of attention, self-confidence and defective vision 2. Gets favors from parents without deserving them 3. Mother tells him he is bad and gives him his own way 4. Teacher scolds him and shows him she does not like him	

the analysis should contain a comparison of data which includes a review of each item with all other items in mind.

As a necessary corollary, the synthesis should follow the analysis. After all parts of the data have been described, defined and compared, there must be an integration of all parts into an organized whole. When all the available facts have been organized into a unit, the examiner is ready for the interpretation or diagnosis of the case and the prognosis or outlook for the future. This is necessarily a subjective process involving judgment and discrimination in arriving at an inference of relationships. However, the subjective element can be reduced to a minimum if the examiner approaches his task with the scientific attitude. The validity of the interpretation depends upon the experience, training, expertness and good judgment of the investigator. The remedial measures applied in any given case will depend upon the interpretation of all of the assembled facts. The interpretation in turn is dependent upon a carefully developed case history.

There are two[1] groups of cases to be considered in the application of the case-study technique to problem cases in school: the corrective case and the remedial case. The corrective case is one that is susceptible to treatment within the pedagogical resources of the school. The remedial case is one which, because of complicating factors and the consequent need for prolonged investigation, requires study and adjustment by a specialist. It is cases belonging to the second group for which the psychiatrist is especially needed. Some of the more generally recurring corrective types of problems which can best be solved by the case-study technique include the failing child, the child who is educationally retarded, the child who does not concentrate, one whose interests have not been aroused, the bright trouble maker who learns his assignments easily and then gets into mischief, the lazy child who is in reality a sick child, the disciplinary case involving problems of morality and character adjustment, the maladjusted per-

[1] MORRISON, H. C., *The Practice of Teaching in Secondary Schools*, Univ. Chicago Press, 1926.

sonality involving nontypical emotional behavior, including shyness, fears and exaggerated aggressiveness, and the pupil in need of educational and vocational guidance.

Two aims borrowed from clinical psychology[1] may well be adapted as the objectives for the application of remedial measures to the problem case in school. First, the work should be preventive and corrective. The fundamental causes of the difficulty should be discovered, and, wherever possible, the child should be guided in helping himself. Guidance should aim to bring about more complete integration in the personality of the individual and better adaptation to his environment. Secondly, the work should be educative. The significance of the diagnosis and remedial measures should be definitely impressed upon parents, guardians, teachers, probation officers and others who deal with the individual. Since the ultimate end of all case study is individual and social improvement, the possibilities for the case-study technique in education are almost unlimited.

C. Personality and Mental Hygiene Tests

Tests designed to measure traits other than intelligence and achievement have been designated by various names including character, interests, attitudes, mental hygiene and personality tests. Personality and mental hygiene tests have included almost every trait of the individual. Most mental hygiene and personality tests have been published in periodical or monograph form. An analysis[2] was made of 85 personality and mental hygiene tests as found in 29 psychological, sociological and educational periodicals from their inception to 1934. So far only a few of these tests are available for public use. Although these tests were analyzed on the basis of eight criteria, the discussion which follows is limited to types of reactions measured, validity and reliability.

1. Types of Reactions Measured.—Table 48 lists the types of reactions which the tests attempt to measure. This

[1] Mateer, Florence, *The Unstable Child*, New York, Appleton, 1924.

[2] Horsch, A. C., and Robert A. Davis, Mental hygiene and personality tests, *Amer. J. Sociol.*, 1935, 40, 646–658.

table shows the predominance of the study of emotions and introversion-extroversion. One of the major aims of mental hygiene is to stabilize emotions. Normal individuals show what is conspicuously absent in the abnormal, the presence of such balancing factors as power of inhibition, emotional control and nervous stability. The majority of early tests have been constructed along the lines set forth by Woodworth in his Psychoneurotic Inventory and many have used the same questions. The purpose of the Woodworth test is to identify individuals who are emotionally unstable. The Laird Mental Hygiene Test, which is also influenced by the Woodworth Inventory, is designed to discover persons in need of adjustment and to measure quantitatively the degree and kind of mental deviation. The test is valuable in that it detects students in need of mental treatment, who otherwise

TABLE 48.—DISTRIBUTION OF 85 PERSONALITY AND MENTAL HYGIENE TESTS ACCORDING TO TYPES OF REACTIONS MEASURED

Reactions	Frequency	Per cent
Alertness	1	1.2
Annoyance-aversion	1	1.2
Ascendance-submission	6	7.0
Conforming-nonconforming	2	2.3
Depression-elation	1	1.2
Emotion	14	16.5
General	21	24.7
General attitude	4	4.7
Good citizenship	1	1.2
Home environment	2	2.3
Honesty-dishonesty	4	4.7
Introversion-extroversion	11	13.0
Opinions	2	2.3
Persistence	1	1.2
Preference	2	2.3
Self-sufficiency	1	1.2
Self-assurance	1	1.2
Sociability	7	8.3
Social intelligence	1	1.2
Will temperament	2	2.3
Total	85	100

would be overlooked until more serious difficulty is encountered. Tendler[1] states that his test of emotional insight is valuable as an approach to emotional behavior in its normal phases.

Laird, Marston and Heidbreder published almost simultaneously tests designed to measure introversion-extroversion. Other typical tests of this classification include Conklin, Determining of Normal Introversion-extroversion Differences, Gilliland and Burke Objective Measure of Introversion and Neymann-Kohlstedt Diagnostic Test for Introversion-extroversion.

It is difficult to classify these tests according to their degree of objectivity because there is much variation. All are classified as objective tests, although the subjective element is not easily eliminated since at times the individual may be tempted to "work" the test and give the normal reaction to a situation rather than the natural or personal reaction which he would give in action.

Difficulty is also encountered in attempting to classify these tests according to construction as questionnaire, inventory or rating scales. The Woodworth Psychoneurotic Inventory is classified both as inventory and questionnaire. The same is true of the revisions of the Woodworth test as Woodworth-House Mental Hygiene Inventory and the Woodworth-Mathews Questionnaire. A questionnaire is in reality one form of an inventory test. Gilliland and Burke believe that the questionnaire is the best single method devised for measuring sociability. Laird's Personal Inventory is in the form of a graphic scale, while the Heidbreder Self-ratings and Preference is an inventory test. Typical of the questionnaire are Jones's Personnel Questionnaire, Symond's Social Attitudes Questionnaire and Allport A-S Reaction Test. Typical of the rating scales are the Haggerty-Olson Wickman Behavior Rating Schedules and the McGill Pre-school Character Rating Chart.

2. Validity and Reliability of Tests.—Forty-three per cent of the 85 tests provide validity coefficients and the majority are validated by correlation with ratings. The range of

[1] Tendler, A. D., A preliminary report on a test for emotional insight, *J. Appl. Psychol.*, 1930, 14, 122–136.

validity coefficients of these tests is from 0.04 to 0.96 with a median coefficient of validity of 0.638. The small percentage of tests which supply validity coefficients does not necessarily imply that they have low validity, but it does indicate that authors have not carefully refined their measures. The establishment of validity is probably the most difficult problem confronting those developing these tests because the concept of normality has not been clearly defined.

Of the 85 tests studied only 53 per cent have expressed reliability coefficients. The range of coefficients is from 0.40 to 0.98 with a median coefficient of 0.861. Although only a little more than half of the tests examined furnish reliability coefficients, it is noteworthy that the median coefficient of reliability is 0.861, which is higher than might be expected in view of the intangible nature of mental hygiene and personality traits. This fact suggests that tests may be developed in these fields with sufficient reliability to justify their use as instruments for diagnosing both group and individual traits.

3. The Bernreuter Test.[1]—The Bernreuter Personality Test is designed for high-school and college students and is diagnostic in that it attempts to measure four important traits. However, these traits are not entirely unique, because the intercorrelation coefficients for the various parts range from 0.28 to 0.95. The test consists of 125 items, each of which measures more than one trait. The weight that the items carry for each trait is determined by the effectiveness with which they measure that trait when they are given to a group selected for that trait by means of other tests. The traits measured include the neurotic tendency, self-sufficiency, dominance and introversion. The test for neurotic tendency correlates significantly with the other measures and may be used alone when less time for testing is desired.

The items are stated in the form of questions and are answered by encircling "yes," "no" or "?" Each answer has a plus or minus value which varies with the trait measured. Four stencils provide different values for these answers and

[1] BERNREUTER, R. G., *Personality Inventory*, Stanford Univ. Press, 1931.

the total score is the algebraic sum of the plus and minus quantities. For example, the question "Do you daydream frequently?" is scored as follows: neurotic tendency, yes, 2, no, −2, ?, 0; self-sufficiency, yes, −4, no, 4, ?, 1; introversion, yes, 1, no, −1, ?, −1; dominance, yes, −3, no, 3, ?, −1.

Typical items in this test follow:

Questions which predominantly measure the neurotic tendency:
1. Can you stand criticism without feeling hurt?
2. Do you frequently feel grouchy?

Questions which predominantly measure self-sufficiency:
1. Does it make you feel uncomfortable to be "different" or unconventional?
2. Do you think you could become so absorbed in creative work that you would not notice the lack of intimate friends?

Questions which predominantly measure introversion:
1. Do you worry too much over humiliating experiences?
2. Do you experience many pleasant or unpleasant moods?

Questions which predominantly measure dominance:
1. Do you ever complain to a waiter when you are served inferior or poorly prepared food?
2. Do you lack self-confidence?

In addition to using the method of intercorrelation, the test was further validated by comparing the scores obtained for the various traits with those on the Thurstone-Neurotic Inventory, the Bernreuter Self-sufficiency Test, the Laird C2 Test for Introversion and the Allport Test of Ascendancy and Submission. The coefficients of validity, uncorrected for attenuation, range from 0.67 to 0.94. Reliability was calculated by the method of split halves from the test scores of 70 students of Stanford University in the fall quarter and 128 students from the same institution during the winter quarter. The average coefficients for the four parts of the test are 0.90 for neurotic tendency, 0.89 for self-sufficiency, 0.87 for introversion and 0.89 for dominance. These coefficients are high enough to warrant using the test for individual diagnosis. Norms are expressed in terms of percentiles and the tests for dominance and neurotic tendency provide norms for both men and women.

Measurement in the field of personality and mental hygiene is of relatively recent origin and, while there have been numer-

ous attempts to measure various characteristics, only a few such tests cover a sufficiently wide range of traits to make comprehensive diagnosis possible. The majority of available tests represent spasmodic attempts of investigators to measure some trait or tendency which has come to their attention, and a large percentage of them have neither expressed validity nor reliability. It seems possible that a test could be developed which would measure all of the important traits involved in mental hygiene and personality. Such a test if properly developed would indicate wherein the individual's traits are wholesome or undesirable and provide a basis for improvement. Teachers need tests of mental hygiene and personality designed to reveal early symptoms of maladjustment in pupils. The school is interested chiefly in the normal individual and in the use of tests which will identify symptoms of maladjustment in their initial stages.

D. The Relationship of Traits

The relationship of personality traits has been a live question since Floyd and Gordon Allport[1] sought to determine the elements which constitute personality. These investigators tentatively divided the field of personality into four main divisions as follows:

1. Intelligence.
2. Temperament.
   - *a.* Emotional breadth.
   - *b.* Emotional strength.
3. Self-expression (strength).
   - *a.* Extro-introversion.
   - *b.* Ascendance-submission.
   - *c.* Expansion-reclusion.
   - *d.* Compensation.
   - *e.* Insight and self-evaluation.
4. Sociality.
   - *a.* Social participation.
   - *b.* Self-seeking and aggressive self-seeking.
   - *c.* Susceptibility to social stimuli.

[1] Allport, F. H. and G. W., Personality traits: their classification and measurement, *J. Abn. & Soc. Psychol.*, 1921–1922, 16, 6–40.

Intelligence is given first consideration because it determines the success of most of the general adjustments of the individual. Emotional breadth and strength are phases of temperament which measure both the spread and power of emotionality. Self-expression contrasts the assertive, self-expressive, expansive and dominant types of personality with withdrawing, secretive and yielding characteristics. A man who has characteristics of the former type is one who is commonly known as "a man with a personality." The traits under this classification are divided into introversion-extroversion, ascendance-submission, expansion-reclusion, compensation, insight and self-evaluation. An extroverted person finds ready expression of his thoughts and mental images in overt action, while an introverted person directs his thoughts inwardly, dwelling largely in the realm of the imagination and often being the victim of mental conflicts. Difficulties in measuring this reaction are inability to determine whether it is due to a repression or to an actual absence of that element in the individual concerned, and the inability of raters to detect introverted responses.

An ascendant person dominates other individuals in face-to-face situations where conflict of the two egos is involved. An expansive person conveys the personal touch in all that he says or does and gives one the impression of being in full contact with his thoughts and actions. The trait of compensation should consider the complete history of the individual since it is necessary to determine his physical, mental, social or financial limitations as well as perseverance in overcoming his difficulties. The traits of insight and self-evaluation are closely related because they involve the ability of the individual to analyze objectively his own thoughts and motives.

Sociality is characterized by social participation, self-seeking, aggressive self-seeking and susceptibility to social stimuli. Social participation is measured by the active indulgence of the individual in social activities such as dances and clubs and not merely by passive interest in them. Thus, this trait should be measured by the time and energy devoted to these activities.

A self-seeking person may be social in so far as he is able to modify his natural, egotistical tendencies to accord with social influence. An individual is susceptible to social stimuli to the extent to which he is sensitive to the behavior, suggestions, gestures, emotional expressions and physical characteristics of others.

The above classification has represented a nucleus around which many investigators have worked. The chief difficulty has been to analyze the total personality in such a way as to discover specific traits which are all inclusive in themselves. It is probable that no one trait of personality is sufficiently specific to be exclusively measured. The traits of introversion and extroversion have frequently been investigated and yet several investigators have found little or no relationship among their different measures. For example, Hovey[1] found no intercorrelation among the three alleged measures of extroversion-introversion developed by Laird, Conklin and Heidbreder. Guthrie[2] found no correlation between the measures of Laird and Heidbreder or between these measures and other indications of introversion and extroversion based upon his interpretation of the concept. Gilliland[3] gave four different introversion-extroversion tests to a group of 172 students and found the correlation between the different tests insignificant. These facts imply either that there are no specific traits of introversion and extroversion or that investigators do not define these terms in the same way.

The method of studying the organization of personality consists in classifying various traits of the individual and devising tests for their measurement. The traits having been measured, relationship is studied by the statistical device of correlation. Positive coefficients indicate that traits are associated, while negative coefficients indicate inverse relation-

[1] Hovey, B., The effects of general distraction on the higher thought processes in relation to extroversion-introversion, M. A. thesis, Univ. of Oregon, 1927.

[2] Guthrie, E. R., Measuring introversion-extroversion, *J. Abn. & Soc. Psychol.*, 1927, **22**, 82–88.

[3] Gilliland, A. R., What do introversion-extroversion tests measure? *J. Abn. & Soc. Psychol.*, 1934, **28**, 407–411.

ship. The theory of positive correlation assumes that various traits of personality are closely related, indicating that if a person ranks high on one trait he is likely to rank high on several or all other traits. The theory of negative correlation, sometimes referred to as compensation, assumes that a person who ranks high on one trait is likely to rank low in some other trait. For example, the individual of superior intelligence is likely to have poor sociability, while artistic persons will be temperamental and emotionally unbalanced. Both of these points of view are equally fallacious when stated in the extreme. Personality traits appear to be positively related but the coefficients are usually not high. Intelligence and physical ability correlate to the extent that it may be said that those who have high intelligence are generally superior in height, weight and other physical measures. Likewise general intelligence correlates positively with most desirable traits. This is true, of course, when large numbers of cases are taken into consideration.

There is also evidence that some traits tend to group themselves according to a general pattern. For example, the extrovert person is likely to be dominant, expansive, aggressive and to enjoy social participation. The introvert is likely to be reclusive, submissive and asocial. However, broad generalizations cannot be made. The same individual may demonstrate introvert tendencies in one situation and extrovert reactions in another. Individuals are also likely to show marked fluctuations in the degree to which they possess various traits. Psychographs show that individuals may have pronounced positive tendencies on some traits and slight or even negative tendencies on others. Such variation in the manifestation of different traits also contributes toward individual and distinctive personalities.

E. Environment and Training

In order adequately to determine the influences of environment and training upon personality and mental hygiene traits, it would be necessary to use the experimental approach and

determine the influence of different types of environment upon such traits. Such an approach is difficult because we cannot conveniently subject children to various types of environment. However, the personality traits of children who have been

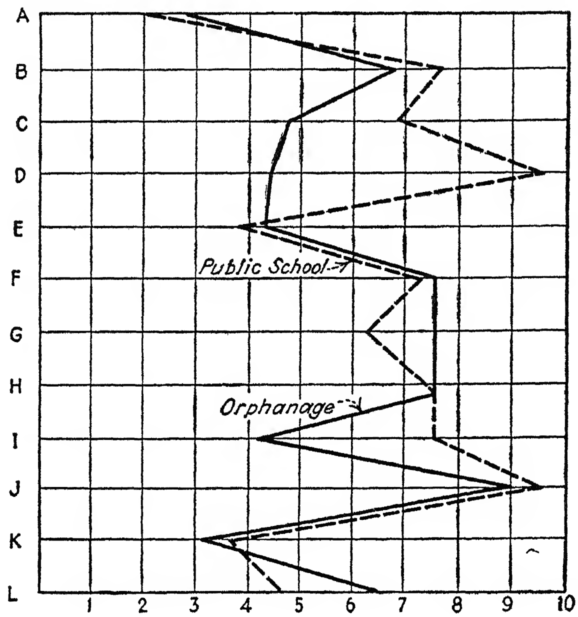


FIG. 25.—Superimposed will-profiles of the median child of the orphanage and public-school groups as measured by the Downey Group Will-temperament Test.

reared under different environmental conditions, such as orphanages and regular homes, may be compared.

Figure 25[1] shows a comparison of orphanage and public-school children on the Downey Will-temperament Test, which includes measurement of 12 traits of personality. The performances of 55 orphanage and 55 public-school children were compared on the basis of their scores on this test after they were equated on the basis of chronological age, intelligence

[1] HARRELL, M. T., and ROBERT A. DAVIS, The effect of institutional life on character traits as evidenced by the Downey Will-temperament Test, *J. Abn. & Soc. Psychol.*, 1929–1930, 24, 330–341.

quotients, school grade and the number of years which they had previously attended school. When the profiles in Fig. 25 are compared, the orphanage group is lower than the public-school group (except on A) on "all speed and fluidity of reactions" items (A, B, C, D,). On the "aggressive traits" (E, F, G, H) the orphanage median child is equal to or above the public-school child, equality being expressed in the score on "finality of judgment" (H). In the "carefulness and persistence" group of traits (I, J, K, L) the orphanage group is lower in all but "volitional perseveration" (L). On the traits considered by Downey as "pivotal traits" (E, I) the orphanage median child showed a better balance between "motor impulsion" (E) and "motor inhibition" (I), these scores being 4.04 and 4.21 respectively, while the public-school group differed on these scores by 3.80 points. The medians of the total will-temperament score for the two groups differ by 4.73 points, the public-school children making the higher score. The majority of the marked differences between orphanage and public-school children are statistically significant.

Although the findings of this study are not conclusive, they indicate that many traits of this particular test are affected by differences in environmental influence. The technique used might also be applied to a study of the traits of those who have spent varying lengths of time in reformatories, delinquent homes and penitentiaries. It is generally believed that both personal and social attitudes of individuals in the majority of such institutions become increasingly more undesirable as they continue to serve their sentences. However, there is wide variation in the management and discipline of such institutions as evidenced by the fact that in some of them attitudes of inmates toward life and society become more desirable under the institution's regime. Whether the attitudes of the inmates become more or less desirable would appear to depend upon the methods and policies of the different institutions. Likewise the personality and character traits of children reared in homes are directly affected by the methods of discipline and morale of parents and guardians. The home and

school afford the most practicable means for the development of desirable traits.

The findings in the majority of studies designed to show the results accomplished by psychiatrists and child specialists have been favorable, although the criteria for evaluating their work may be questioned. The usual procedure is to have subjective estimates of improvement by parents and teachers. There has also been the added limitation that the improvement noted cannot easily be separated from that which might result from increased maturity, home and other influences.

Greene[1] studied the value of psychiatric work in the case of 517 high-school girls in the schools of New York City over a period of five years. The records of these girls were followed in the effort to determine the extent to which their behavior had improved following psychiatric treatment. The study shows that the girls referred to the psychiatrist for poor scholarship and not for physical disorders and nervousness improved in 50 per cent of the cases, while those whose problems arose from physical disorders and nervousness improved in 80 per cent of the cases. These facts taken at their face value would tend to indicate that the work of the psychiatrist is more effective when it deals with physical and nervous maladjustments than with problems of scholarship.

Lee and Kenworthy[2] studied 200 cases which had been treated in clinics and found definite improvement in 48 per cent of the cases and partial improvement in 31 per cent more. While the majority of studies indicate that marked improvement may be expected as a result of the work of the psychiatrists, it will probably never be possible to determine objectively all of the values which accrue from the services of such persons. Much of the value of these men will probably not manifest itself until after a long period of years, and consequently it could not be estimated by studies of the type reported.

[1] Greene, Elizabeth, Results of five years' psychiatric work in New York City high schools, *Ment. Hygiene*, 1927, 11, 542–557.

[2] Lee, P. R., and M. E. Kenworthy, *Mental Hygiene and Social Work*, New York Commonwealth Fund, Division of Publications, 1929.

F. Some Educational Implications

The implications[1] of psychiatry and mental hygiene permeate the entire program of education, involving its methods, organization and philosophy.

1. **The child's potentialities for education should be determined at an early age.** The child's abilities and interests should be discovered as early as possible so that educational and vocational goals may be anticipated. Instruments for measuring general intelligence and special aptitudes as well as those for determining the child's emotional and social traits are helpful in discovering abilities. However, such measuring instruments, even when reliable and valid, can give only partial pictures of separate and isolated aspects of the total personality, and should be supplemented by facts relating to family and social background, physical characteristics and other important information. It is only through intensive study of the child in all of his reactions and traits that his intellectual and temperamental fitness for various types of educational work and vocational possibilities may be gauged.

The school should especially attempt to stimulate students who show promise of originality and creative ability and inspire them to their highest level of achievement. Pupils of low intelligence cannot be expected to progress as rapidly as brighter pupils or to have the same immediate interests and vocational ambitions. It is certain that such students should be provided with a different type of program than those of average or superior native ability.

2. **Teachers should be selected not only for scholarship but for stimulating and inspiring personality.** Teachers are generally selected according to academic and intellectual standards with little regard for their emotional and social qualities. Many teachers themselves have poor mental hygiene and create undesirable traits in their students. During the child's early years the teacher is idealized and his behavior

[1] For an excellent discussion of several implications see F. L. Patry, Psychiatry and the junior high school, *Junior-Senior High School Clearing House*, November, 1933.

readily influences the child's later responses to school. A distinguishing characteristic between good and poor teachers is found in the personal confidence engendered by the teacher in his students. The influential teacher understands the limitations and potentialities of his students and is sympathetic toward their differences. He also searches for positive traits in his students rather than for defects and limitations.

The teacher who acts on the belief that he is entertaining a great and superior mind and hence is expected to be excused for harsh, sarcastic attitudes toward his students sets up a barrier to achievement that no amount of material efficiency can overcome. Teachers should react from day to day to the same situation in the same way so that the child may have a sense of security and know what is expected of him in the classroom. Evenness of temperament on the part of the teacher creates a feeling of security which is necessary for efficient work and even for self-confidence in later life. Mental hygiene tests are useful in directing attention of teachers to their own undesirable traits and in furnishing a stimulus for self-analysis and improvement.

3. **Although homogeneous grouping is desirable for classroom organization, classification on the basis of group similarities should not imply that pupils will be similarly treated.** Whether in a large school system where homogeneous grouping is the practice or in the small school where heterogeneous classes are found, opportunity should be provided for personal relationships with each pupil in order to discover his interests and individual characteristics. Formal class work should also be supplemented by personal conferences, projects, reading and outside work. By emphasizing the socialization program pupils themselves should be trained to recognize and appreciate differences in their classmates. The child who is able to excel others from the standpoint of scholarship in formal courses should be led to see how he is surpassed by other pupils in other activities of the school. This training would prevent self-satisfaction and complacency so dangerous to his future development and success.

The schools have tended to emphasize the passing of examinations and earning of credits. Under such a practice attention is centered mainly upon examinations and earning of credits and not upon the pupils themselves. The mark which a pupil receives should be made in terms of the relative standing of those in the class. However, students should not be marked on the basis of normal probability unless the number in the class is sufficiently large to justify a wide range of ability and to insure nonselectivity. However, not all the factors necessary for the evaluation of a student are revealed through objective examinations. The appraisal of students should not only include marks obtained in objective examinations but the teacher's estimate of the student's own effort and understanding of his schoolwork. It is only through such a practice that the school may free itself from the highly mechanized method of group instruction in which information and specific skills are all that are measured.

4. Courses should be both coordinated and varied. In many schools where students are allowed to take small amounts of work in various fields of subject matter, there is always the possibility of developing disintegration and superficiality. Courses in different fields should be arranged so that one course inevitably leads to another and more advanced one in the same field, in order that there may be continuity and soundness of preparation. On the other hand courses of study should be varied to allow students to select under guidance a sufficient range of subjects to explore their abilities and interests. The junior high school is meeting this need in the large school systems. In the small school systems where there is a uniform course of study for all, coordination as well as variation of subjects are difficult to realize but are possible through individual methods of instruction. In the determination of fields of specialization knowledge should be integrative as well as cumulative.

In addition to the regular subjects there should be courses which deal with vital problems of home, life and society. High-school pupils should be allowed opportunity to discuss

freely and candidly important problems of conduct and behavior. Through opportunity for free discussion of the problems of adjustment to life a wholesome attitude toward oneself and society is encouraged. In the organization of courses of study provision should also be made for participation in extra-curricular activities. Such activities, whether they take the form of student government, debating, dramatization or athletic programs, allow pupils to give expression to their emotional and social reactions as well as aid them in discovering vocational aptitudes. Student counselors, psychiatrists and deans of boys and girls, wherever they are possible within the resources of the school, greatly aid the socialization program.

5. Although extreme cases of maladjustment are rarely found in school, the method of studying them is similar to that used for the relatively normal child. Pronounced cases of maladjustment which require the services of a psychiatrist are very rare, but the method will not be essentially different from that used by the teacher in studying the complaint problem. The procedure will involve obtaining facts regarding the child's physical and mental characteristics, home and parental background, emotional and moral reactions. After the facts have been gathered and interpreted, a program for improvement may be planned.

G. Summary

Personality is defined as the integrated sum total of the individual's traits, while mental hygiene implies such balancing factors as power of inhibition, emotional control and nervous stability. The significance of personality and mental hygiene is found in a study of all of the individual's reactions in relationship to the whole personality.

The undesirability of behavior traits is determined by ratings of parents, teachers and mental hygienists. Behavior problems of children are those forms of conduct which are considered undesirable in terms of personal and social attitudes of adults. Teachers tend to consider as undesirable traits which interfere with achievement and the reaction of pupils to the teachers

themselves; parents emphasize as unwholesome traits which are in opposition to parental authority, social customs and moral standards. Mental hygienists, while recognizing the undesirability of such traits, stress as undesirable withdrawing and recessive characteristics. Most undesirable traits have their origin in the physical and mental condition of the child, and, while apparently not undesirable when they first appear, may without discovery of their cause and correction later lead to serious difficulties. Mental hygienists, because of their understanding of the significance of traits and their recognition of causative factors in behavior, have a sounder point of view than parents and teachers. Classification of behavior problems is valuable in calling attention of parents and teachers to unwholesome forms of behavior in children and furnishes a stimulus for improvement.

The case-study technique is a means of studying the child according to his various traits in relation to himself and his social setting. Standardized forms developed in the fields of psychology and psychiatry may be used as guides for studying the problem child. Since extreme cases of maladjustment are rare, the teacher should be able to deal with the majority of problem cases.

Inventories, rating scales and questionnaires have been constructed for the measurement of personality and mental hygiene traits. However, many of these instruments are lacking in reliability and validity and only a few include a sufficient number of significant traits to diagnose difficulties accurately. Tests are needed which measure important traits and tendencies in order that the school may detect early symptoms of maladjustment. Traits of personality are positively associated, although the relationship is generally not close enough to indicate that a person who ranks favorably on one trait will have a similar ranking on another. The chief difficulty in classifying individuals according to traits and types is that one may demonstrate one tendency in one situation and a different tendency in another. Psychographs also show that an individual may exhibit pronounced fluctuations in the degree to

which he ranks on various traits of personality. Such variation makes each individual somewhat different from every other.

Environment and training are significant factors in the development of desirable traits of personality. Social and emotional traits appear to be more directly influenced by environment and training than intellectual and physical traits. By using the techniques and findings developed in the fields of psychology and psychiatry, the schools have a unique opportunity to aid pupils in recognizing and developing desirable forms of behavior.

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